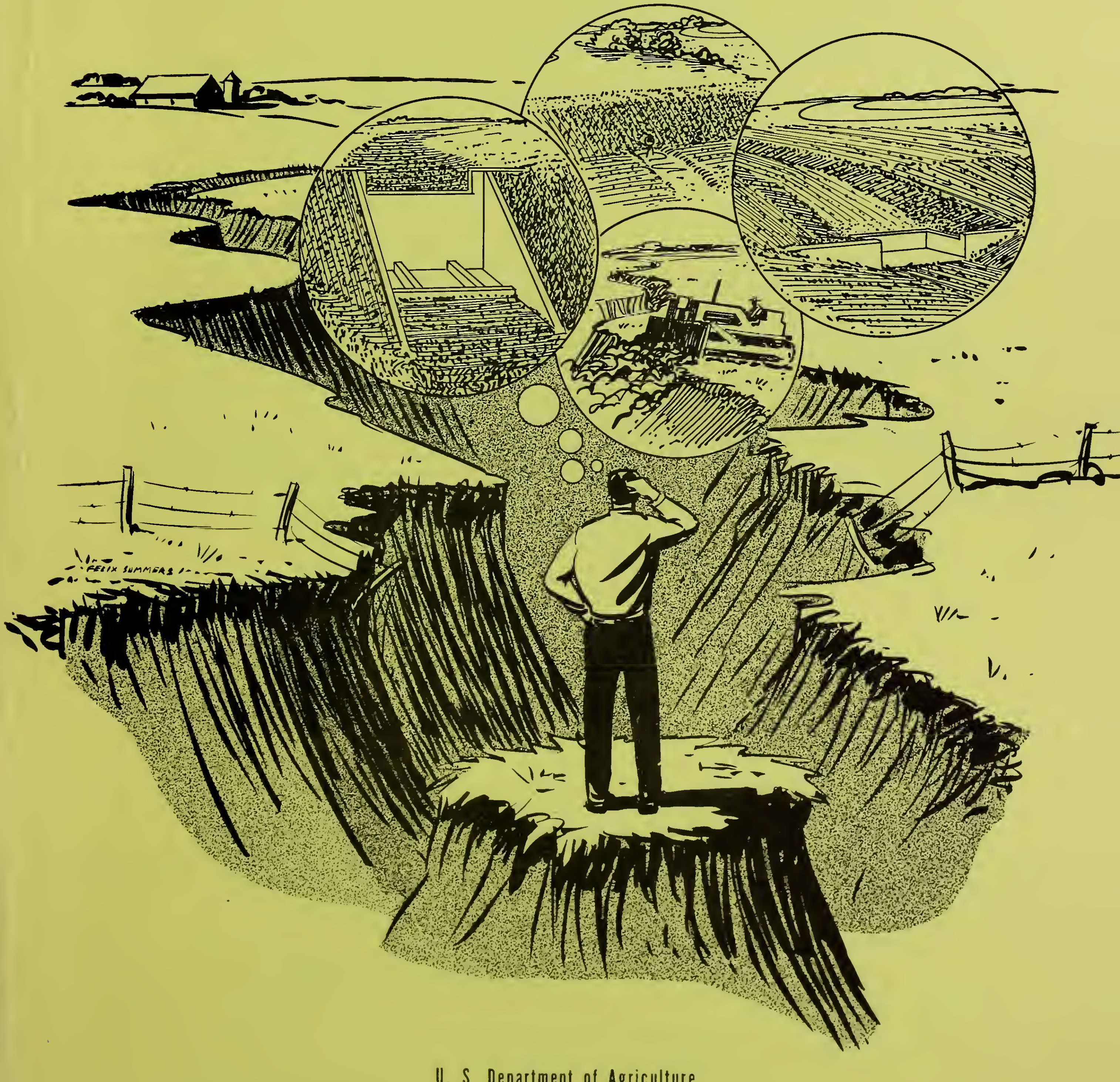
STRUCTURES in Soil and Water Conservation



U. S. Department of Agriculture
Soil Conservation Service

A TEXT F ONTROL

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The mater to give the conse e place of structi on. The important ed with accompanying discussions as to their use, adaptability, advantages, and limitations. Training in design is not a part of this text.

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October 1962

GENERAL FUNCTIONS OF STRUCTURES

Structures are efficient, supplemental control measures in soil and water conservation work. Good vegetative practices, together with proper land use, are indispensable in a sound soil and water management program. But there are many instances where vegetative measures and simple practices alone are inadequate to handle a concentration of water. In such a case, permanent structures play an important part in reinforcing or supplementing the other practices.

There are also instances where a high degree of safety and permanence is desirable. Conservation measures may be required which will be good insurance against loss of life or destruction of property. Vegetative control measures are subject to the influences of such uncertain factors as climate, insects, etc., and therefore are not always too dependable. On the other hand, properly designed and installed permanent structures are of long life and dependability.

Structures are normally used for the following soil and water conservation purposes:

I. Grade and gully control.

II. Water storage.

III. Water detention (flood control).

IV. Sediment storage.

V. Surface water inlets to ditches.

VI. Water level control.

VII. Drainage outlets.

VIII. Irrigation.

COMPONENT PARTS OF STRUCTURES

Inlet

Water enters the structure through the inlet, which may be in the form of a box, a weir in a wall, or a culvert-type entrance. The box may be straight or flared, while the wall may be straight, flared, or curved. The culvert-type entrance may be round, square, or rectangular, with a square edge, hood or flared entrance. Vertical walls extending down into the soil foundations under the inlet are known as cut-off walls. Their main purpose is to prevent water seepage under the structure. Similar walls, extending from the inlet to prevent seepage around the ends of the structure, are called headwall extensions. These walls also protect against burrowing rodents.

Conduit

The conduit receives the water from the inlet and conducts it through the structure. It restricts the water within a definite channel. The conduit may be closed in the form of a box or pipe, or it may be open as in a rectangular channel. Cut-off walls or anti-seep collars are usually constructed as an appurtenance of the conduit to prevent seepage adjacent to it. This insures greater structure stability.

Outlet

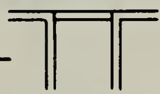
The water leaves the structure through the outlet. Its function is to discharge the water into the channel below at a safe velocity. The outlet may be of the cantilever (propped) type, a simple apron outlet, or an apron with any variation of an energy dissipator to minimize the erosive effect of the water. Cantilever outlets are necessary in locations where the channel grade below the structure is unstable.

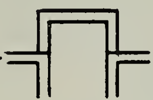
Vertical walls known as toewalls are built around the apron to prevent undercutting. They are similar in construction to cut-off walls under the inlet. "Wingwalls" or vertical walls, extending from the outlet back into the channel banks, protect against the swirling effect of the turbulent water as it enters the channel.

MECHANICAL SPILLWAY NOMENCLATURE

I. DROP SPILLWAY

A. INLET

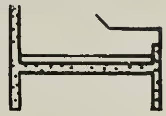
1. Straight ----


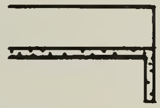
2. Box ------


B. CONDUIT

1. None

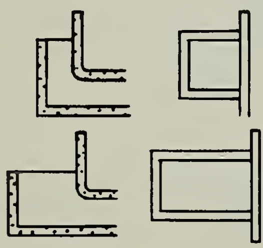
C. OUTLET

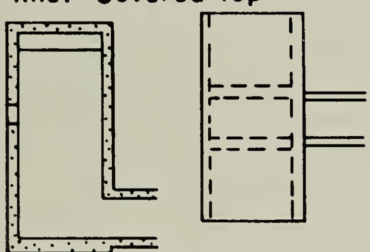
1. Stilling Basin


2. Plain Apron


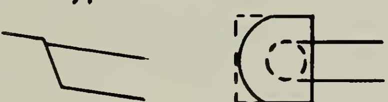
II. DROP INLET SPILLWAY AND CULVERT TYPE SPILLWAY

A. INLET

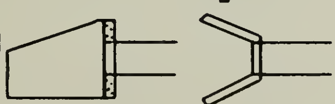
1. Drop Inlet-Open top


2. Drop Inlet-Covered top


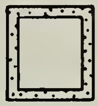
3. Culvert Type Inlet

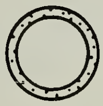
a) Hood


b) Plain

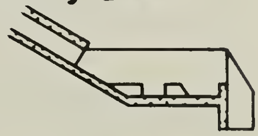

c) Flared


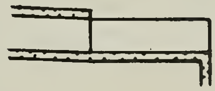
B. CONDUIT

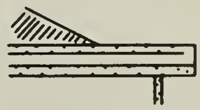
1. Box ------


2. Pipe -----


C. OUTLET

1. SAF Stilling Basin


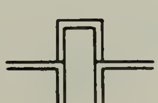
2. Plain Apron


3. Cantilever (Propped)


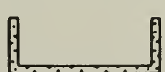
III. CHUTE SPILLWAY

A. INLET

1. Straight ------- (with flared headwalls)

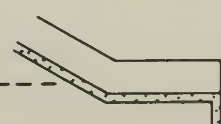

2. Box -------


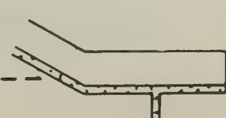
B. CONDUIT

1. Rectangular ---


C. OUTLET

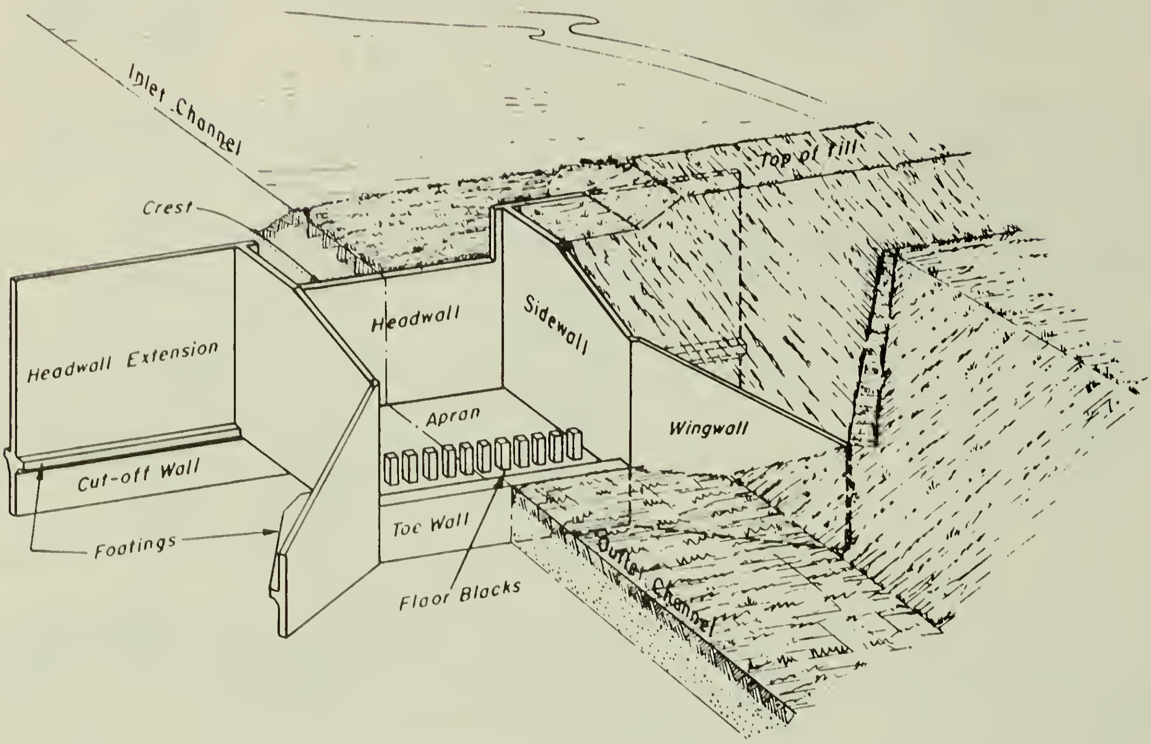
1. SAF Stilling Basin


2. Plain Apron --------


3. Cantilever --- (Propped)


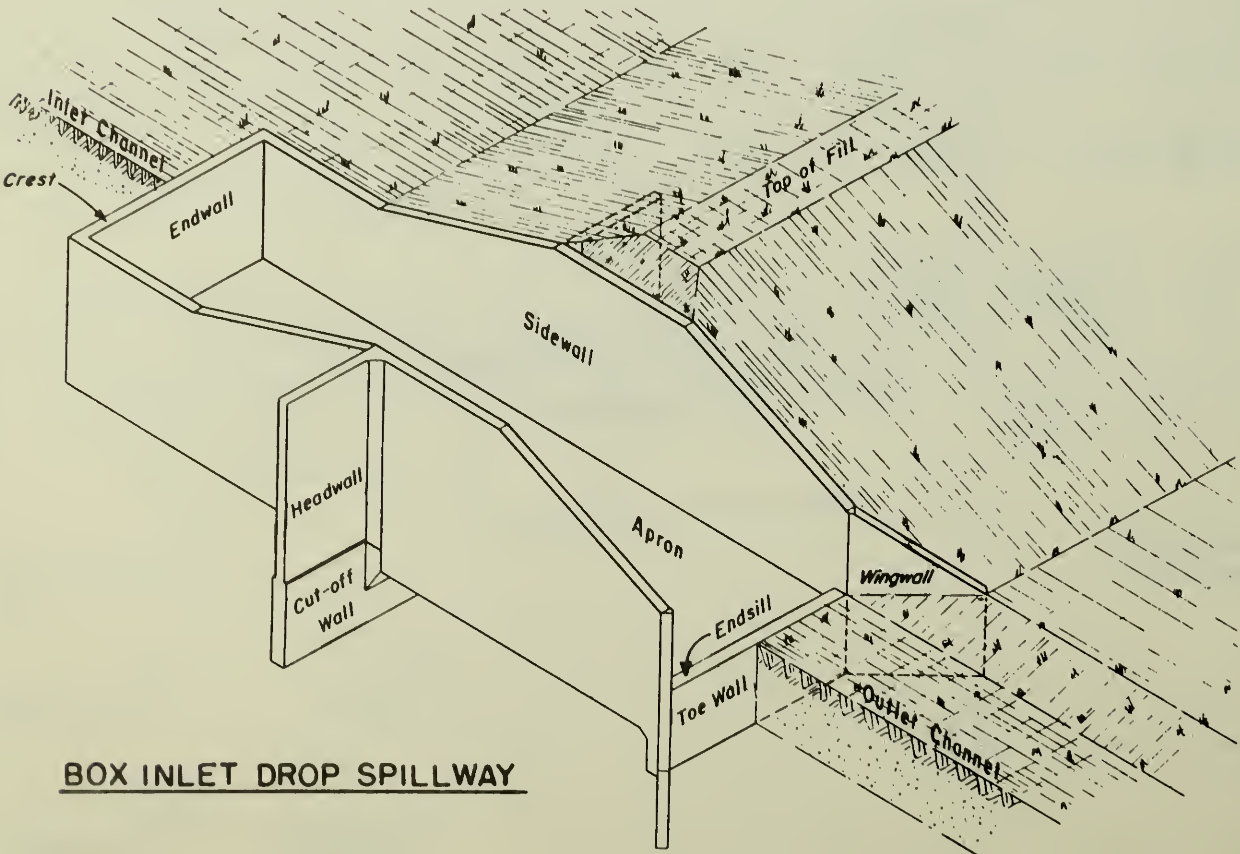
SPILLWAY NOMENCLATURE

STRAIGHT DROP SPILLWAY



PERSPECTIVE VIEW
DROP SPILLWAY
Fig. 1

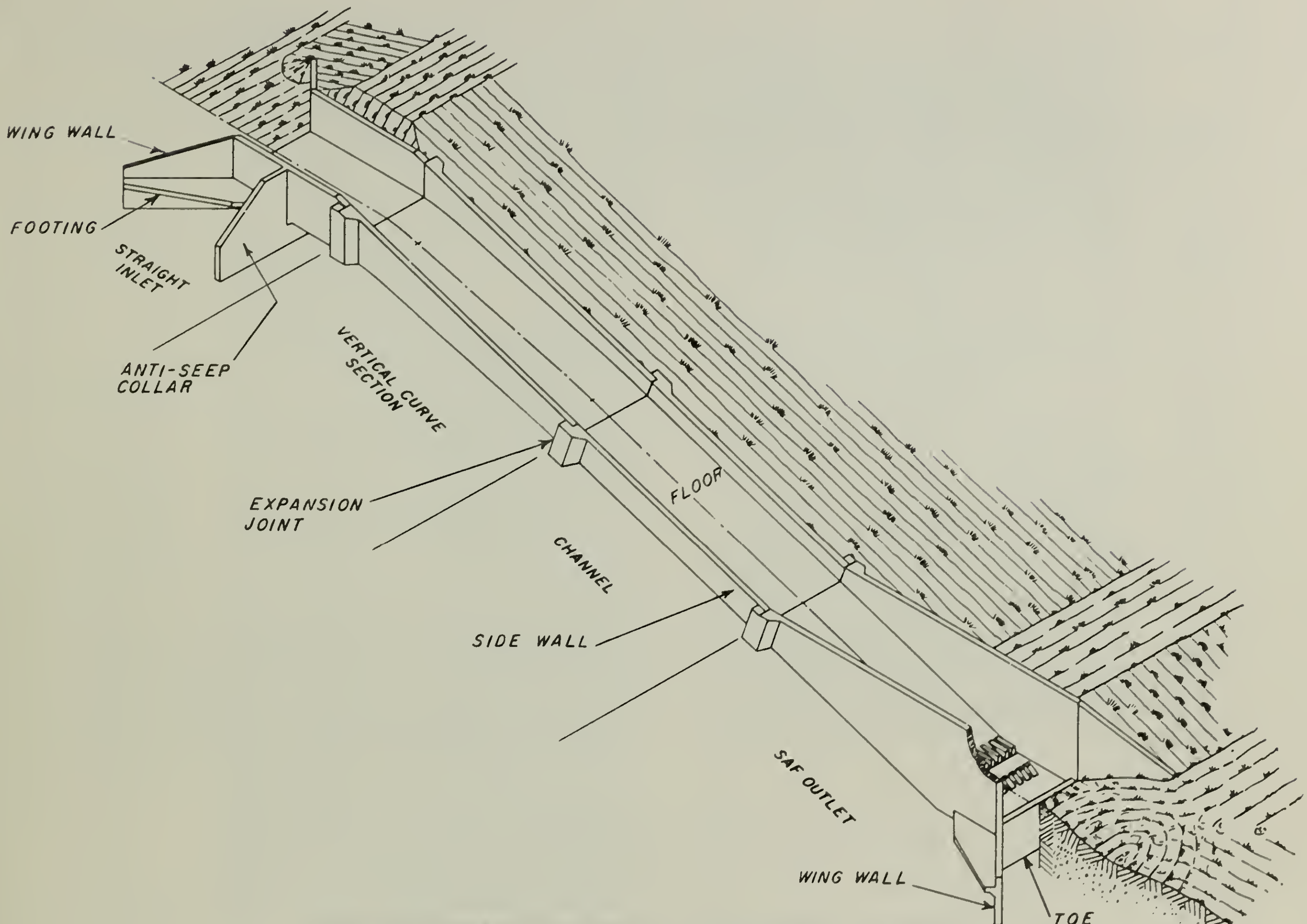
BOX INLET DROP SPILLWAY



BOX INLET DROP SPILLWAY

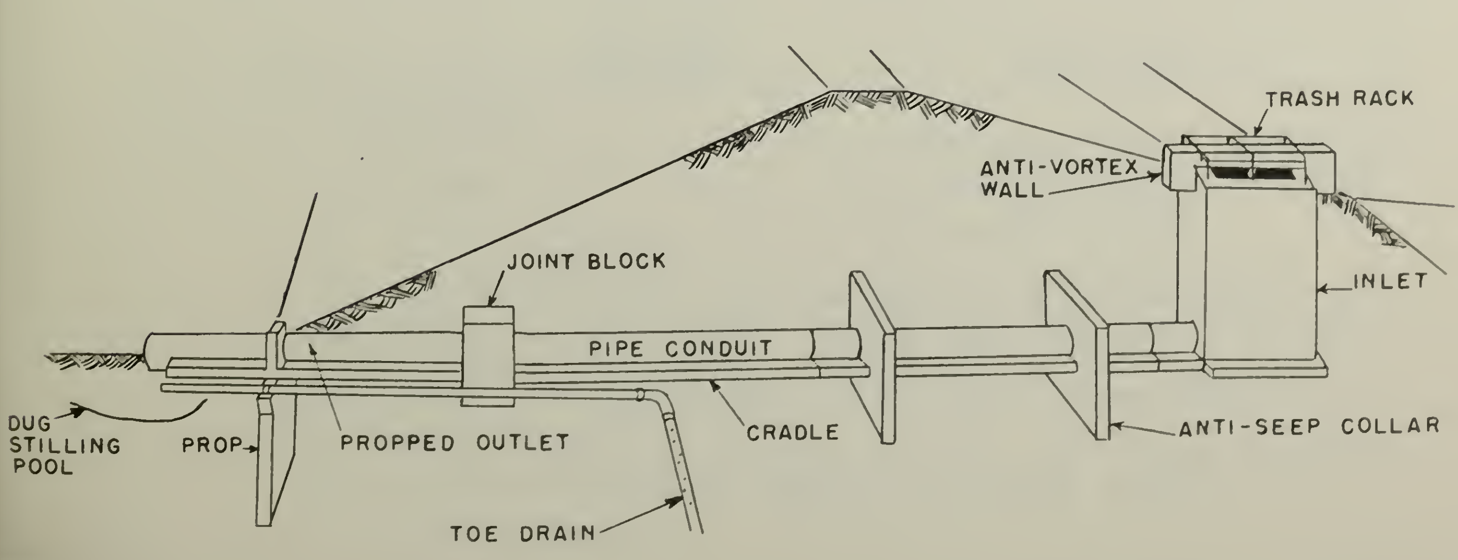
SPILLWAY NOMENCLATURE

CHUTE SPILLWAY



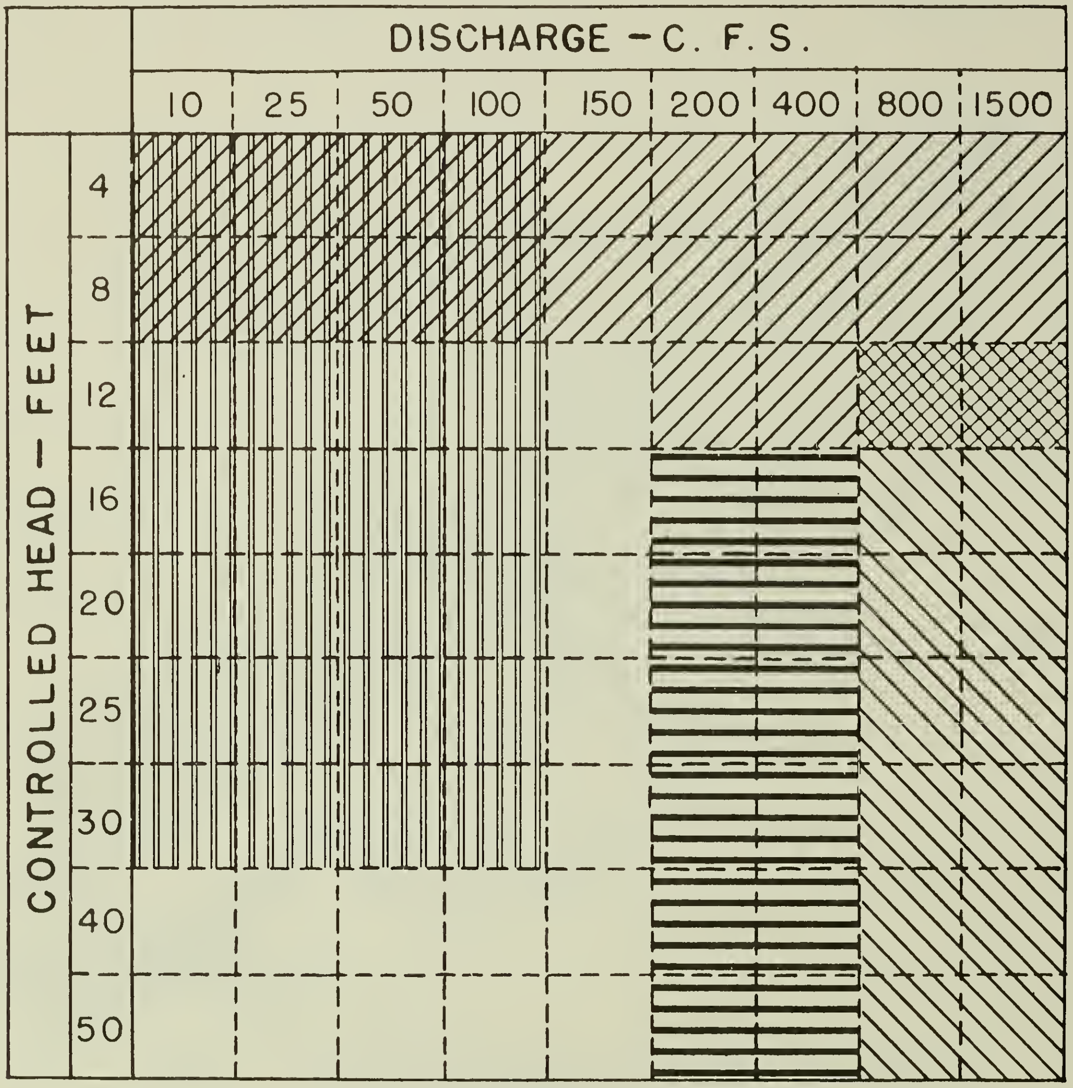
ISOMETRIC VIEW OF CHUTE SPILLWAY

DROP INLET SPILLWAY



GENERAL GUIDE TO STRUCTURE SELECTION

SHOWING MOST ECONOMICAL STRUCTURE AS RELATED TO DISCHARGE AND CONTROLLED HEAD PROVIDING SITE CONDITIONS ARE ADEQUATE.



LEGEND

Straight Drop Spillways

Chute Spillways

Monolithic Drop Inlet Spillways

Drop Spillways or Chute Spillways

Pipe Drop Inlet Spillways

Drop Spillways or Hooded Inlet Spillways

Hooded Inlet or Pipe Drop Inlet Spillways

This diagram is for average field conditions and is based on the most economical structure for the given controls providing the site will permit installation of the structure. Site and foundation conditions will also be important factors in the selection of the type of structure. It will be noted that some conditions provide a choice of structures.

TREATMENT OF GULLIES UNDER VARIOUS CONDITIONS

Slope of Water-way in %	Drainage Area in Acres: 1-2	3-5	6-10	11-15	16-25	26-40	41-80	81-150	Over 150
0-0.5	Above solid lines gullies can								
0.5-2	ordinarily be controlled								
3-4	by blading in and								
5-6	sodding or							Below	
7-8	seeding.					solid line			
9-10					gullies will ordi-				
11-14				narily require permanent					
15-19			structures for reducing grades						
20-25			to provide safe velocities.						
26-35									

If slopes cannot be reduced to those shown as maximum in the above table for seeding or sodding, due to an over-fall or extremely steep portion of channel, or the width of the gully or draw into which water is being discharged is materially less than width of waterway, permanent structures will be required in the vegetative control area.

Ordinarily, a good rule-of-thumb method for type of permanent structure is:

1. Gullies with small drainage area
   a. Low heads-notch spillway dams
   b. High heads-pipe outlet structures
2. Gullies with large drainage areas
   a. Low heads-notch spillway or head spillway
   b. High heads-chutes or drop inlet structures

STRAIGHT DROP SPILLWAY

Description

The drop spillway is a weir structure. Flow passes through the weir opening, drops to an approximately level apron or stilling basin and then passes into the downstream channel.

Materials

It may be constructed of reinforced concrete, plain concrete, rock masonry, concrete blocks with or without reinforcing, and sheet piling, either steel or timber Wakefield.

Functional Use

1. Grade stabilization in lower reaches of waterways and outlets.
2. Erosion control for protection of fields, roads, buildings and other improvements against encroaching gullies.
3. For reducing ditch bottom grades for stabilizing the channel.
4. Serves as outlets for tile and surface water at upper end and along drainage ditches. Where the channel width below the proposed structure site is limited, the box inlet drop spillway is more effective.
5. Serves as a reservoir spillway where the total drop is relatively low.
6. To control tailwater at the outlet of the spillway or conduit.

Adaptability

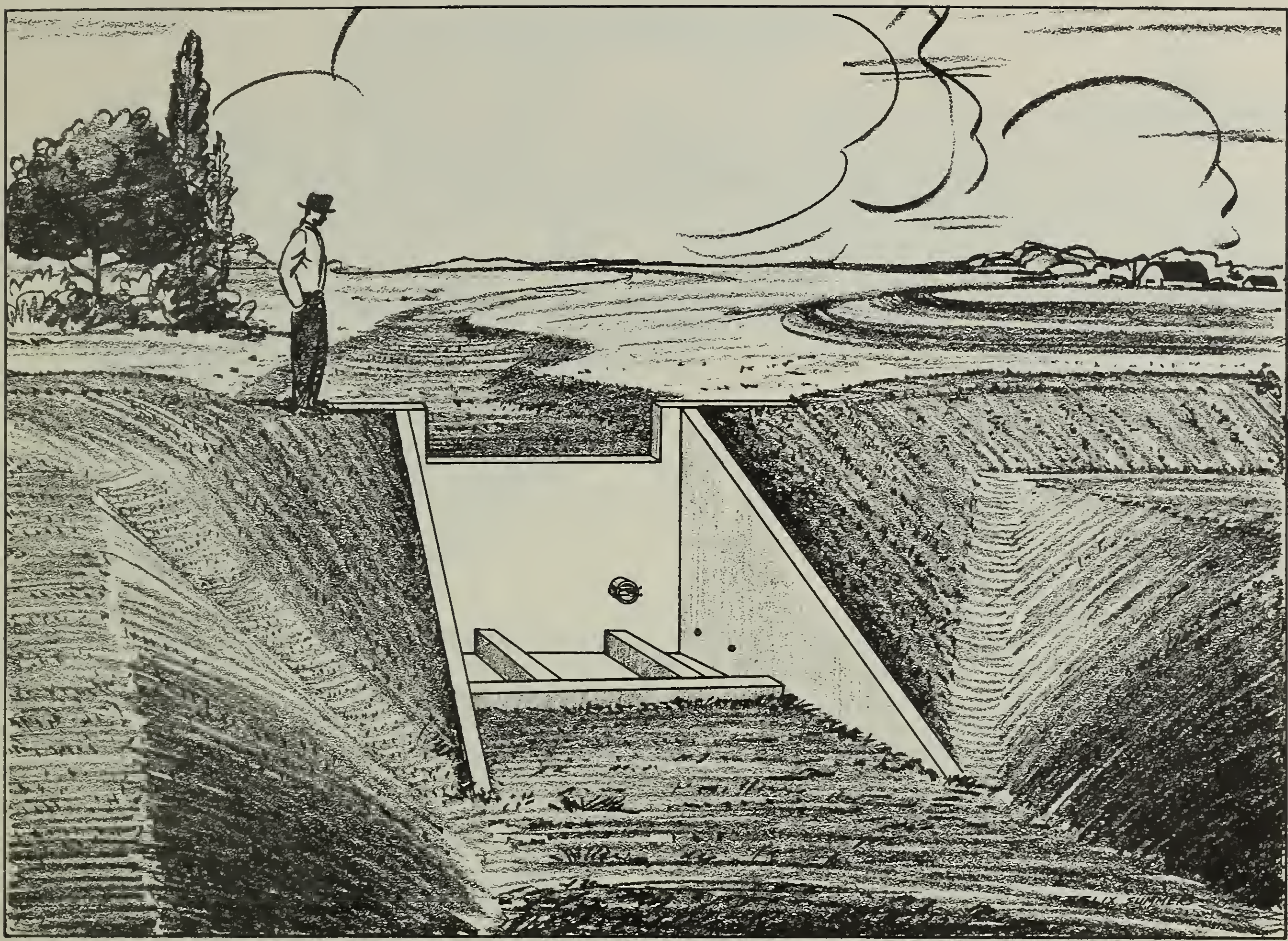
It is an efficient structure for the control of relatively low heads normally up to 8 feet.

Advantages

1. Very stable and the likelihood of serious structural damage is more remote than for other types of structures. However a stable grade below the structure is essential to its stability.
2. The rectangular weir is less susceptible to clogging by debris than the openings of other structures of comparative discharge capacities.
3. When properly constructed, its maintenance cost is lower than other types of structures for most embankment and foundation soil conditions.
4. They are relatively easy to construct. The concrete block type can easily be built with farm labor, while the reinforced concrete type usually requires the services of a contractor.

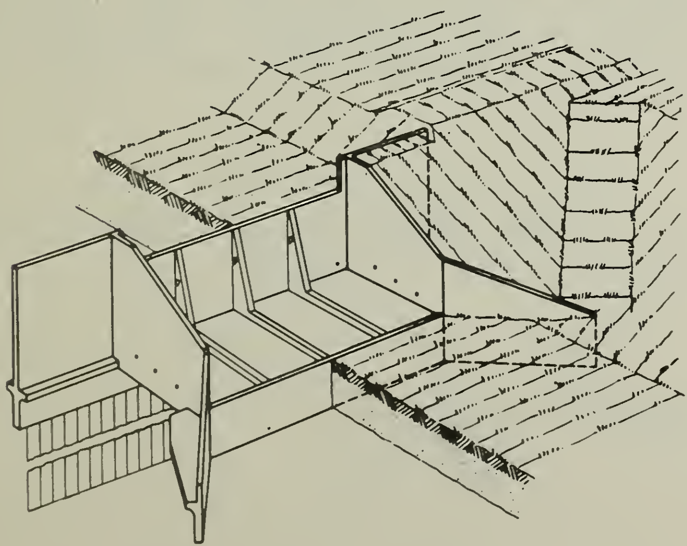
Limitations

1. It is more costly than some other types of structures where the required discharge capacity is less than 100 c.f.s. and the total head or drop is greater than 8 or 10 feet.
2. It is not a favorable structure where it is desired to use temporary spillway storage to obtain a large reduction in discharge.

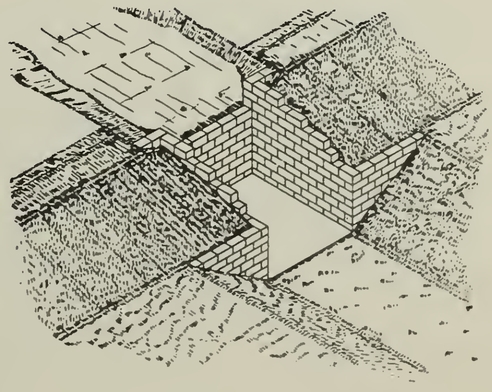


Drop Spillway

SS-1



Reinforced Concrete



Concrete Block

BOX INLET DROP SPILLWAY

Description

The box inlet drop spillway structure is a rectangular box open at the top and at the downstream end. Storm runoff is directed to the box by dikes and headwalls, enters over the upstream end and two sides, drops to an apron and leaves through the open downstream end. An outlet structure is attached to the downstream end of the box.

Materials

Reinforced concrete is best. However, concrete blocks (reinforced) can be used for low overfalls (3 feet) and narrow channels.

Functional Use

The box inlet drop spillway can be used for the same purposes as a straight drop spillway. One of its greatest uses is for grade and erosion control in open drainage ditches where the width of outlet is limited. It can also serve as a tile outlet at the head end of the ditch. Like the drop spillway, it is limited to overfall heights up to 10 feet.

Adaptability

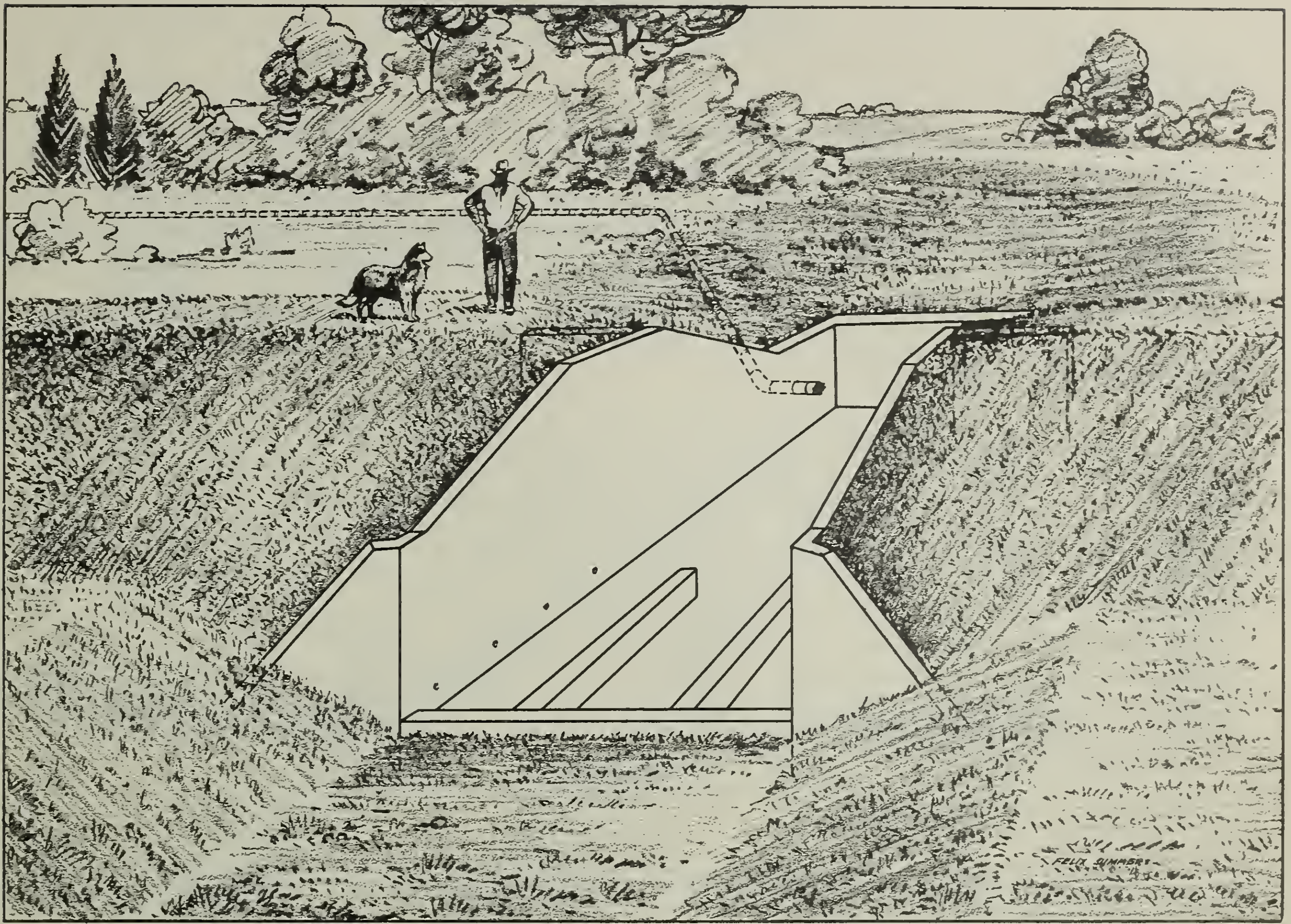
It is particularly adapted to narrow channels where it is necessary to pass large flows of water. The long crest of the box inlet permits large flows to pass over it with relatively low heads, and the width of the spillway need be little, if any, greater than that of the exit channel. The box inlet drop spillway can be easily combined with a bridge to provide a road crossing. The high portion of a side wall can be used as abutments for the bridge. (See sketch SS-7.)

Advantages

Same as for straight drop spillway with added advantage of greater weir capacity for narrow outlet channels.

Limitations

Same as for straight drop spillways.



Box-inlet drop spillway.

SS-4

ISLAND-TYPE SPILLWAY

Description

The island-type spillway uses a drop spillway in the ditch with auxiliary spillways for carrying storm flow around the structure. Either the straight drop spillway or the box inlet drop spillway can be used. When the required weir length of the structure is over twice the bottom width of the ditch, the box inlet drop spillway should be considered.

Functional Use

The island-type spillway is adaptable for use at the head end of drainage ditches to control the overfall. It is particularly adapted to site conditions where the anticipated runoff volume is greater than the capacity of the outlet channel into which the structure empties. This structure can be used only where there is sufficient space of nearly level land on either side of the dam that can be used as an earth spillway. Topography of the ground must be such that the path of overflow around the dam will return to the ditch locations a short distance below the structure without causing damage to the field or ditch banks.

Operation of Structure

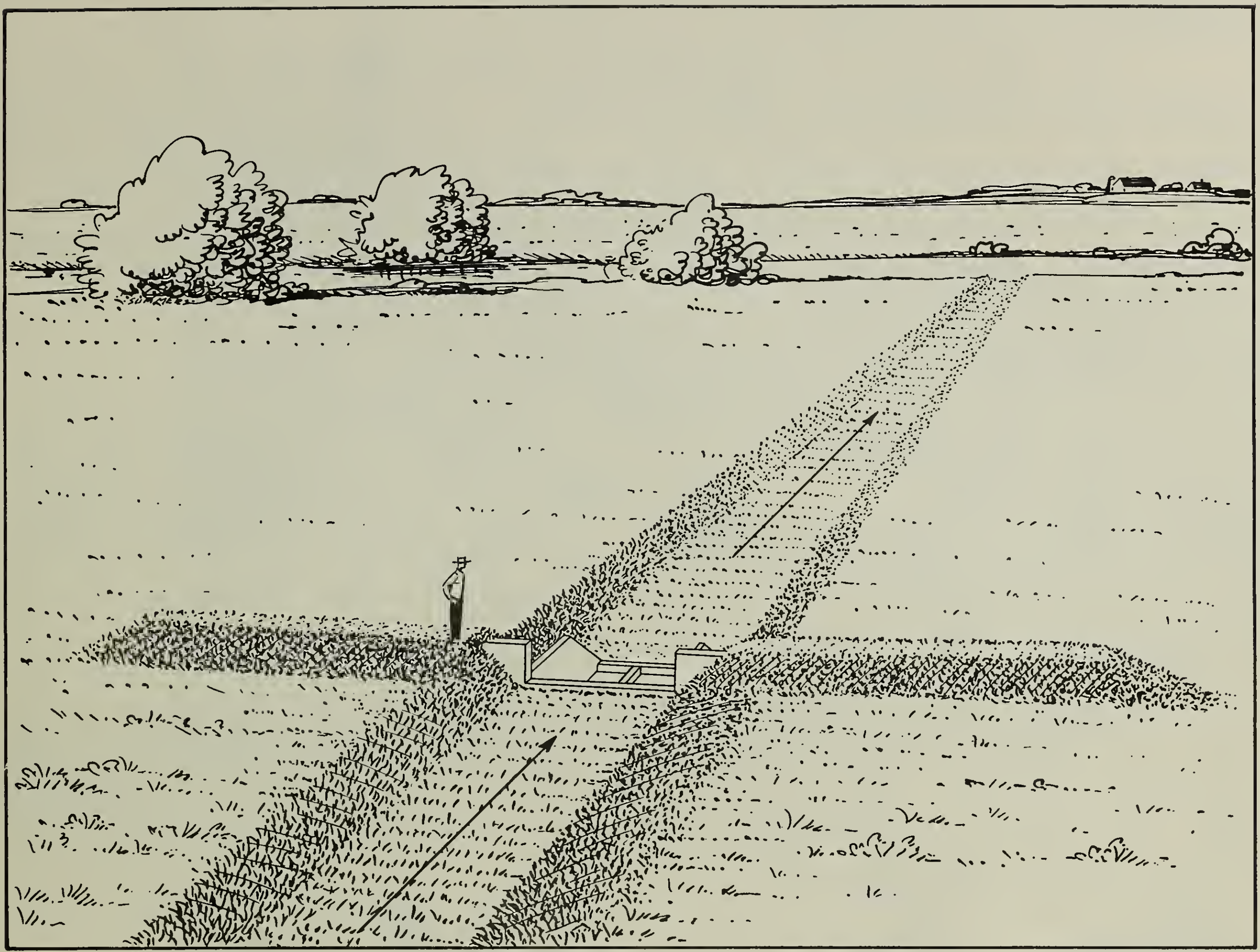
The island-type spillway is proportioned so that the ditch will be full before the overflow around the dam enters the ditch, thereby eliminating the possibilities of bank erosion from flow over the ditch bank. To accomplish this, the crest of the weir must be set below the bottom elevation of the earth spillway, a distance sufficient to provide a weir notch capacity between these 2 points, equal to the bank full capacity of the ditch at the place where the flow from the auxiliary spillway will enter the ditch. Larger flows will then pass around the earth embankment of the drop spillway, forming an island composed of the drop spillway and the headwall extension levees. The waterway above the structure must have the same capacity as the ditch below the dam at the point of overflow. This means that the discharge from the waterway must fill the ditch before the banks of the waterway are overtopped and flow is directed to the auxiliary spillway. It should also be so proportioned that its banks will overflow near the structure as soon as the ditch capacity flow has been reached. In order to force overflow water away from the dam and protect the fill from washing out around the dam, levees extending each way from the dam must be provided.

Advantages

Permits the use of a spillway having a capacity less than that which would be required to handle the total runoff peak discharge.

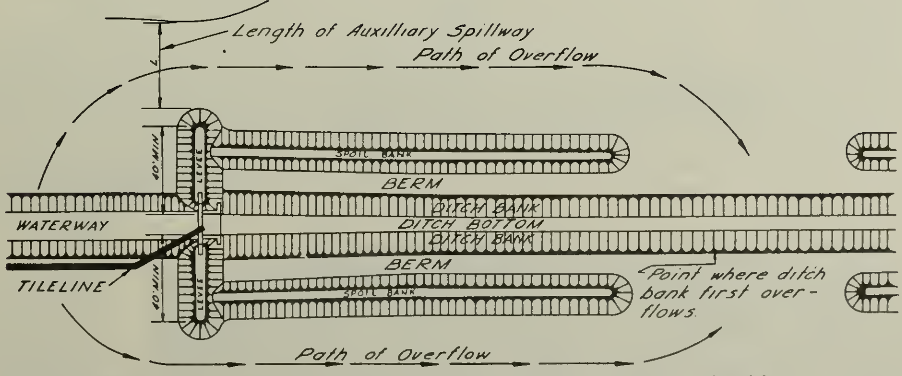
Limitations

Requires the construction of auxiliary spillways in areas which may be cropland and, therefore, harder to maintain the correct grade and elevation.



Island type spillway.

SS-16



PLAN VIEW OF LAYOUT FOR ISLAND TYPE DAM

CULVERT BOX INLET OR DROP BOX

Description

A drop box is a rectangular box open at the top and at the downstream end and has a paved bottom. It may be built as an integral part of a new culvert, or it can be fastened by means of dowel bars to the upstream headwall of an existing highway culvert. Storm runoff is directed to the box by the highway fill. Flow passes over the upstream end and two sides, drops to an apron approximately level, runs into the culvert, and emerges into the downstream channel.

Functional Use

Drop boxes are used to control gradients above culverts in either natural or constructed channel, and, in addition, they may serve as an outlet structure for tile lines in drainage systems. Cattle ramps can be incorporated into the design of the box when the culvert is used as a cattle pass. The drop box is very effective for highway erosion control as shown in sketch SS-21.

Materials

Reinforced concrete is the most commonly used and best material for constructing drop boxes. In some cases, concrete blocks or plain concrete can be used. Material used should be consistent with the expected remaining life of the culvert to which the drop box is to be attached. The addition of a headwall will be required where none exists.

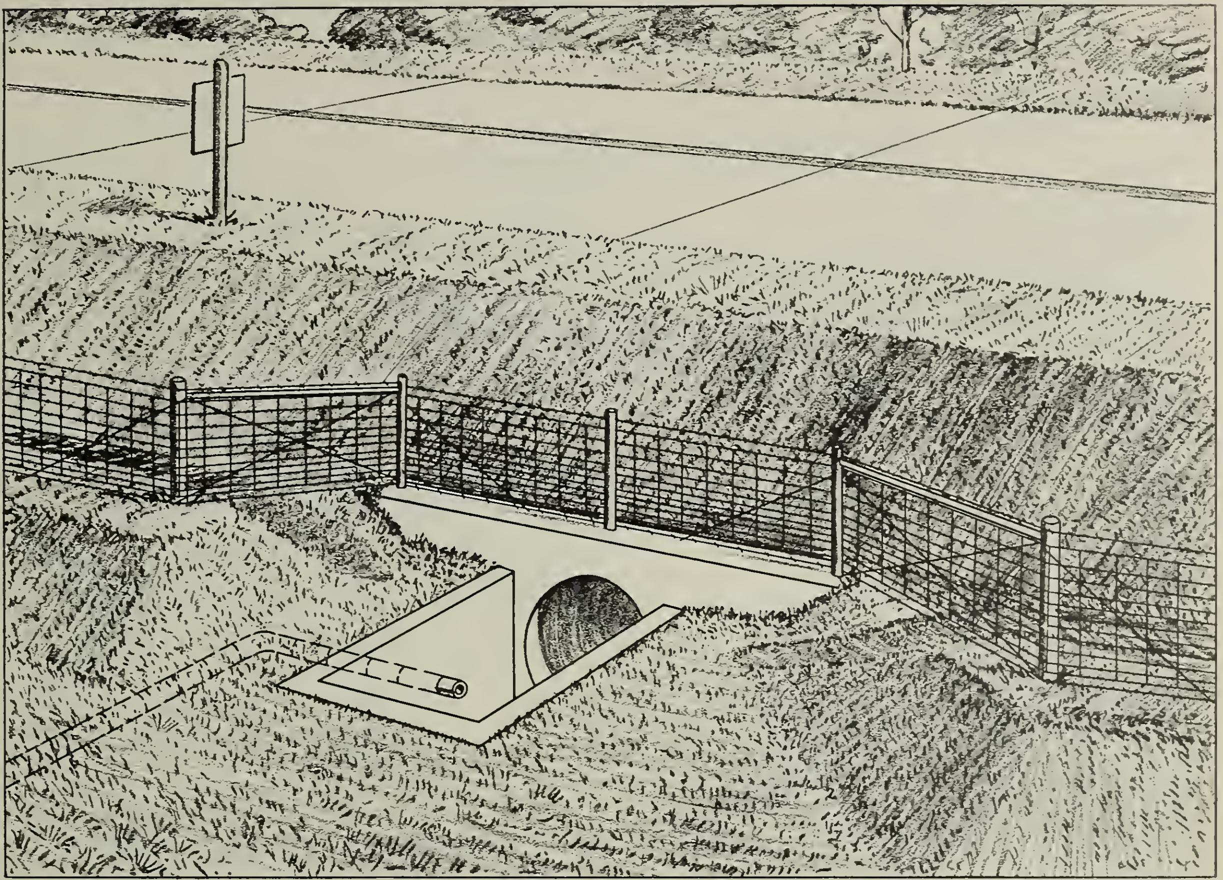
Advantages

It is one of the most economical structures for controlling overfalls because the existing culvert and highway embankment replace the outlet portion of the typical drop spillway. It has the advantage of the box inlet drop spillway in that weir length can be fitted to a narrow waterway.

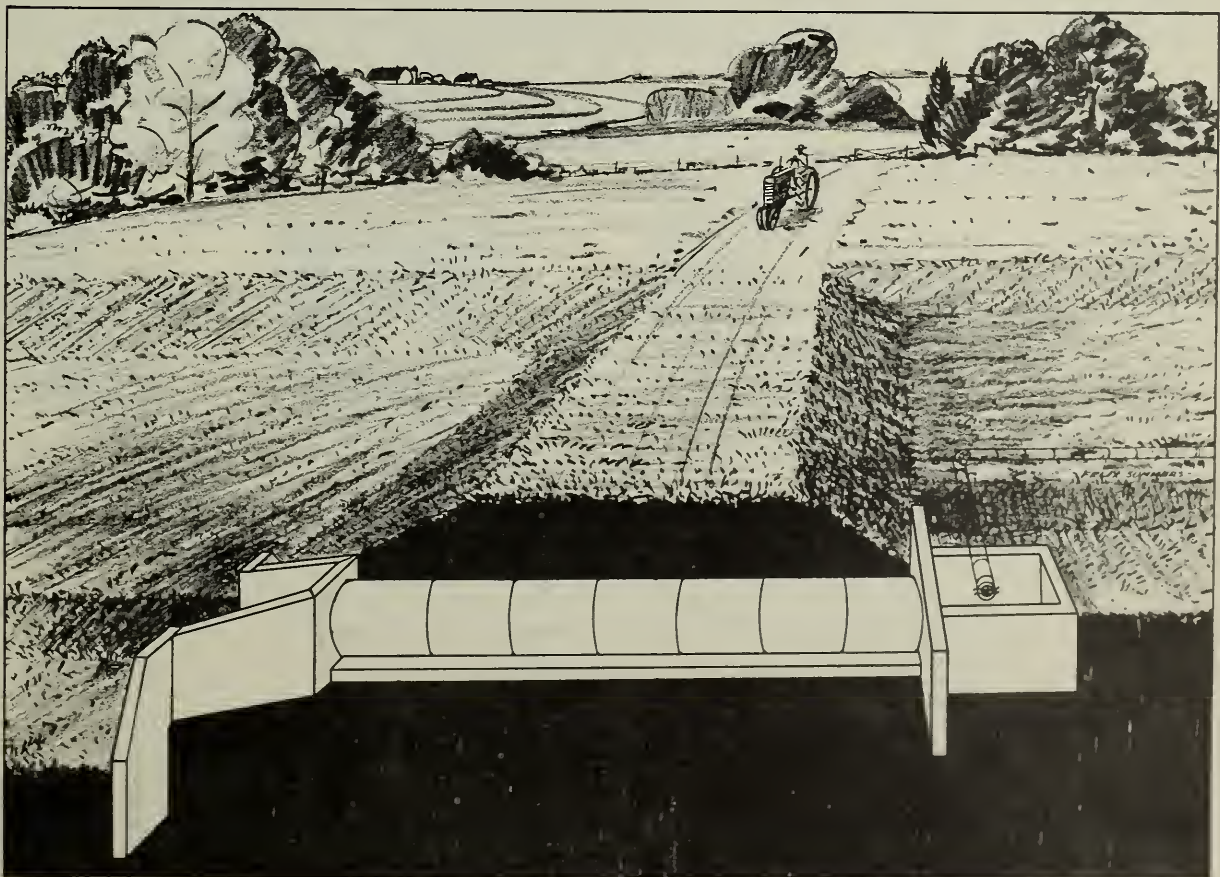
Limitations

1. Requires the availability of structurally sound road culvert.

2. The structure is often attached to a road culvert which is the property of a roadway governing body and therefore requires their permission and may not allow subsequent maintenance and control on the part of the land owner.

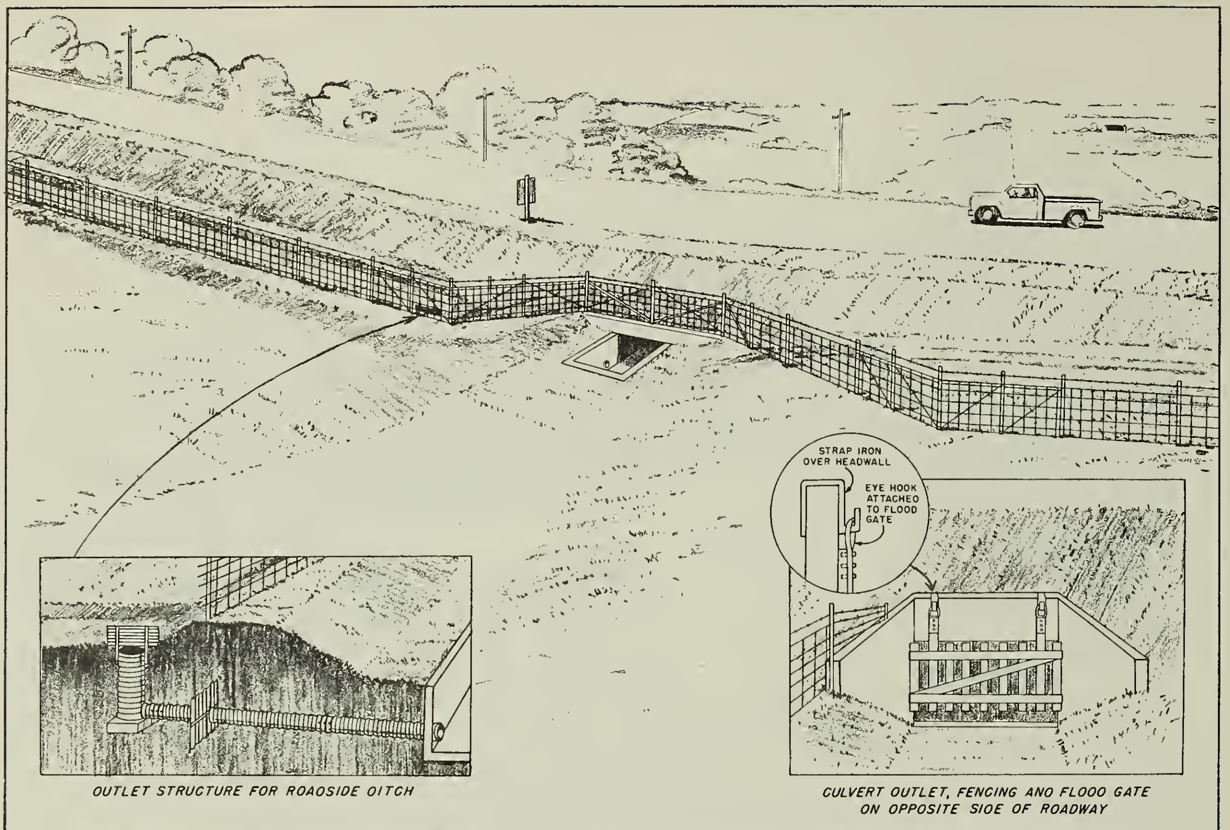


Culvert box-inlet. SS-11



Dry basin type earthfill dam with box-inlet culvert type spillway. SS-9

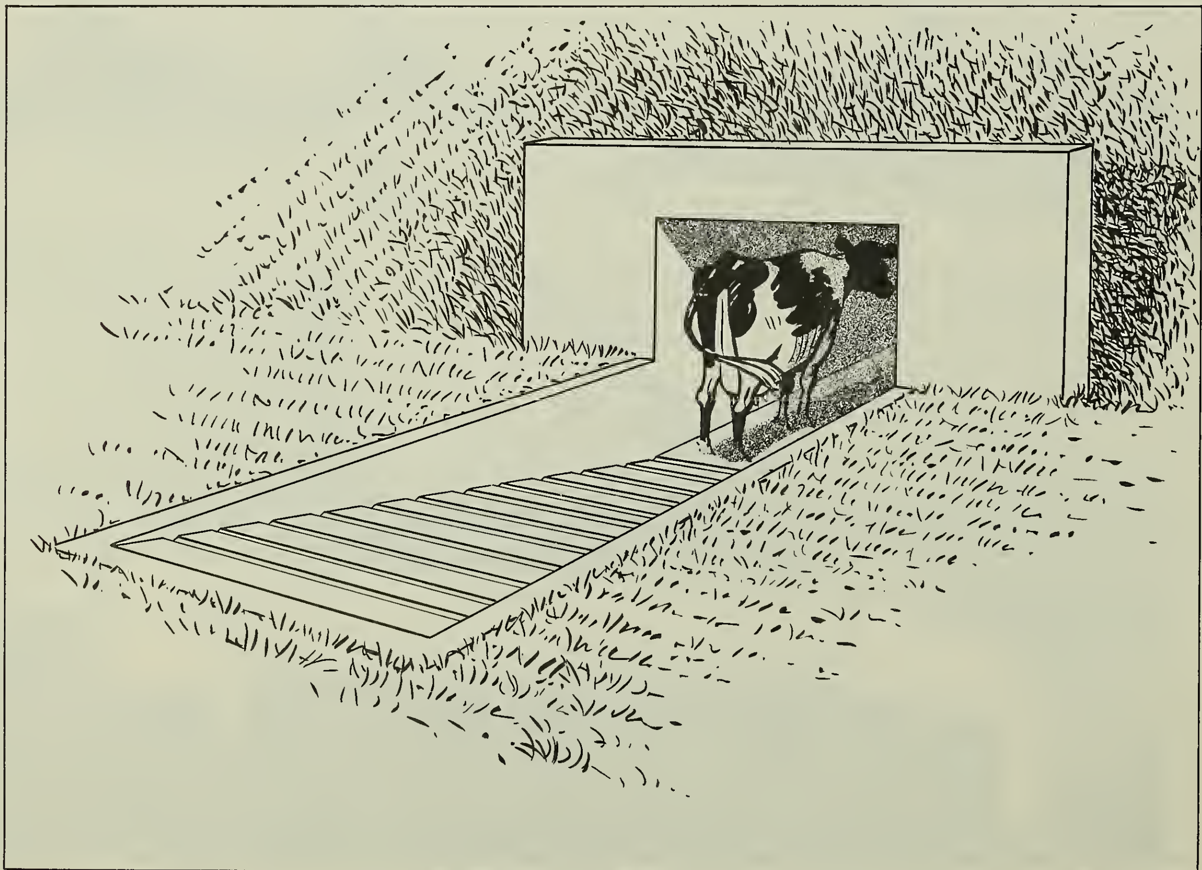
CULVERT BOX INLETS



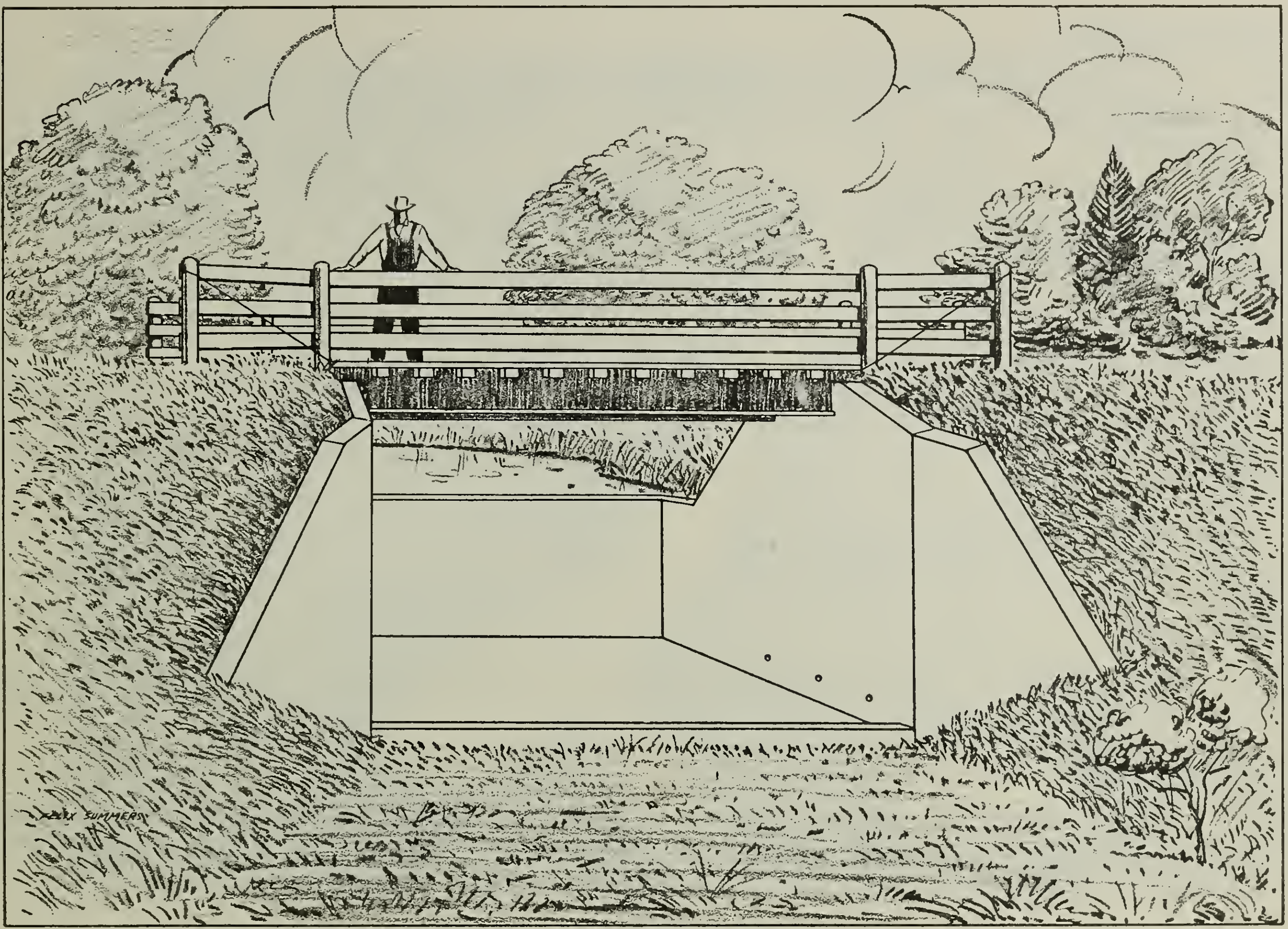
IMPROVED HIGHWAY CULVERT WITH BOX INLET FOR GRADE CONTROL, SAFETY AND MINIMUM MAINTENANCE COSTS

Highway Erosion Control

SS-21

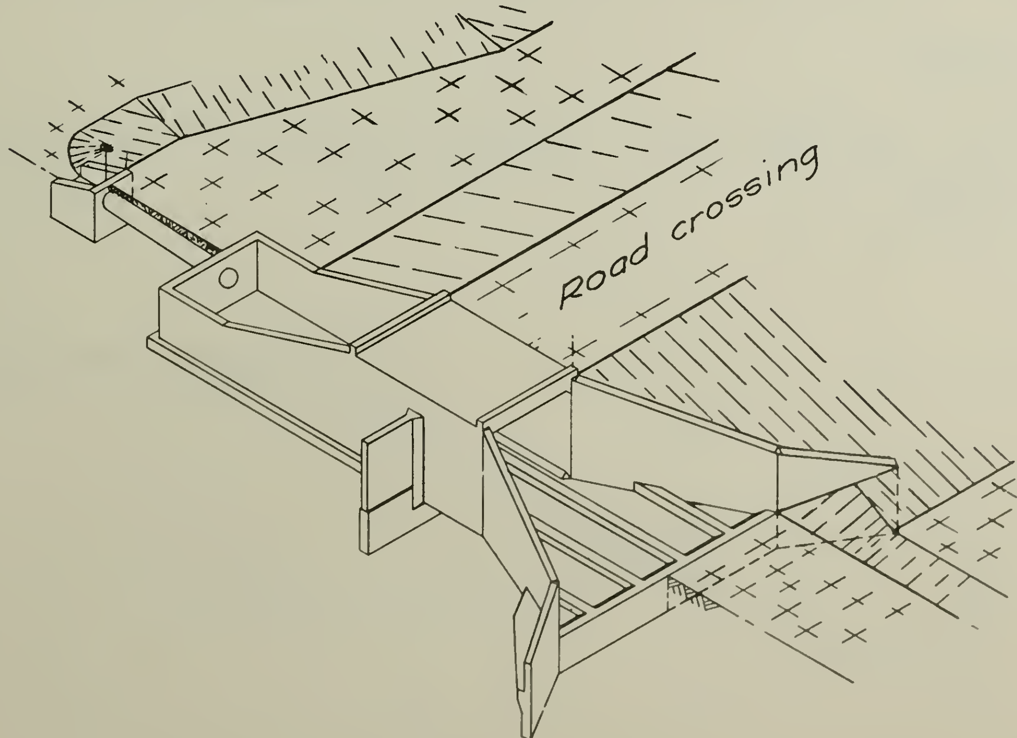


DROP BOX WITH CATTLE RAMP



Box-inlet drop spillway with a bridge over the top.

SS-7



CONCRETE CHUTE SPILLWAY

Description

Chute spillways are defined as open channels with steep slopes in which flow has supercritical velocities. They usually consist of an inlet, vertical curve section, steep sloped channel and outlet. The major part of the drop in water surface takes place in a channel. Flow passes through the inlet and down a paved, steeply-sloped channel to the floor of the outlet.

Material

Reinforced concrete is by far the most widely used material for large chutes as it has been proved to be satisfactory from the standpoint of long life and low construction and maintenance costs.

Functional Uses

1. To control the gradient in either natural or constructed channels.
2. To serve as reservoir spillways for flood control water conservation structures and sediment-collecting structures.

Adaptability

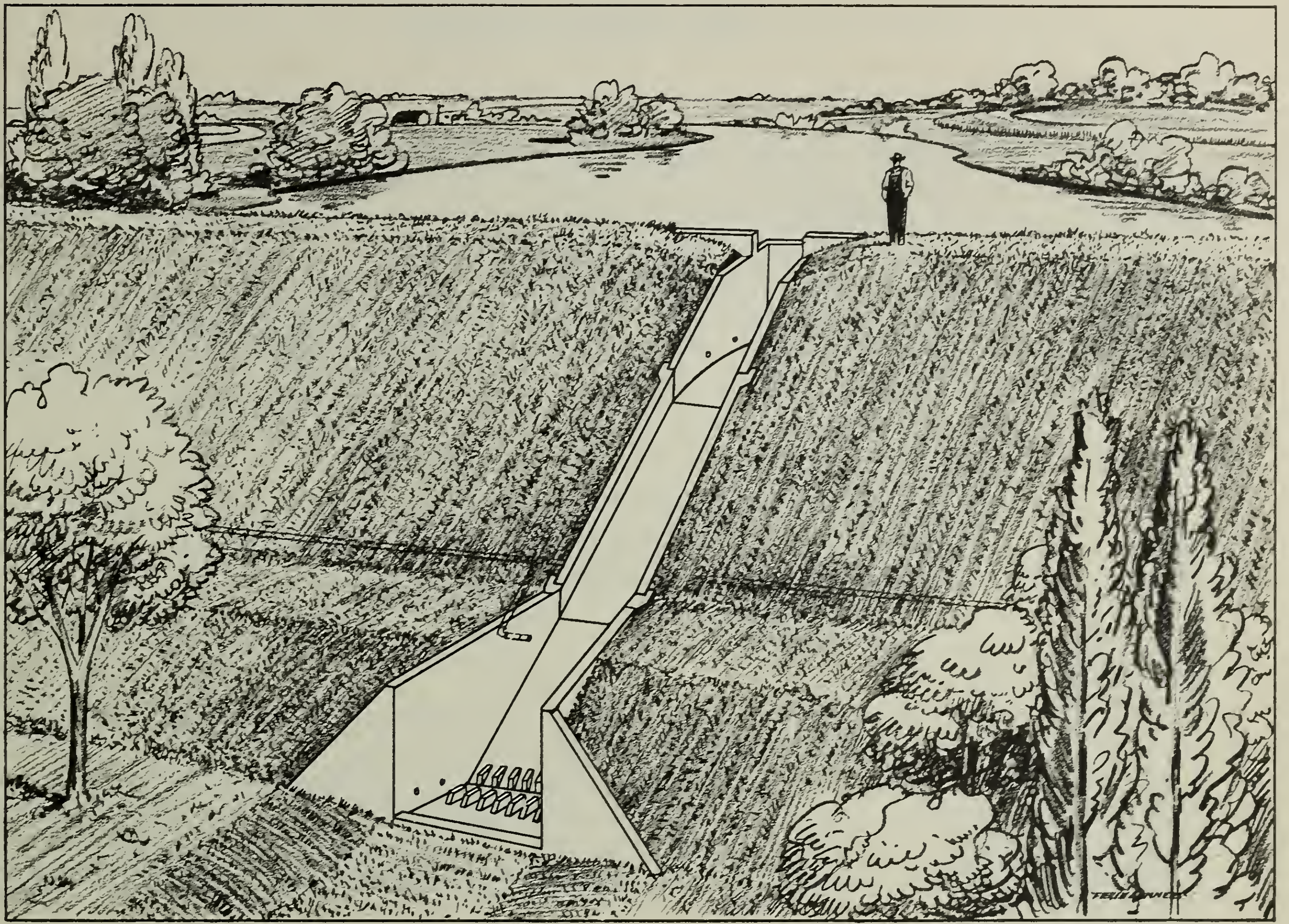
The concrete chute is particularly adapted to high overfalls where a full flow structure is required and where site conditions do not permit the use of a detention-type structure.

Advantages

They usually are more economical than drop inlet structures of the same capacity and drop when larger capacities are required.

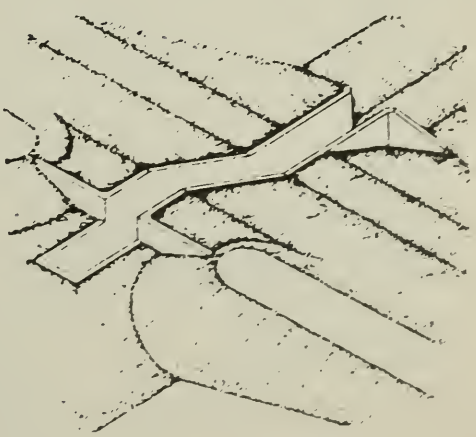
Limitations

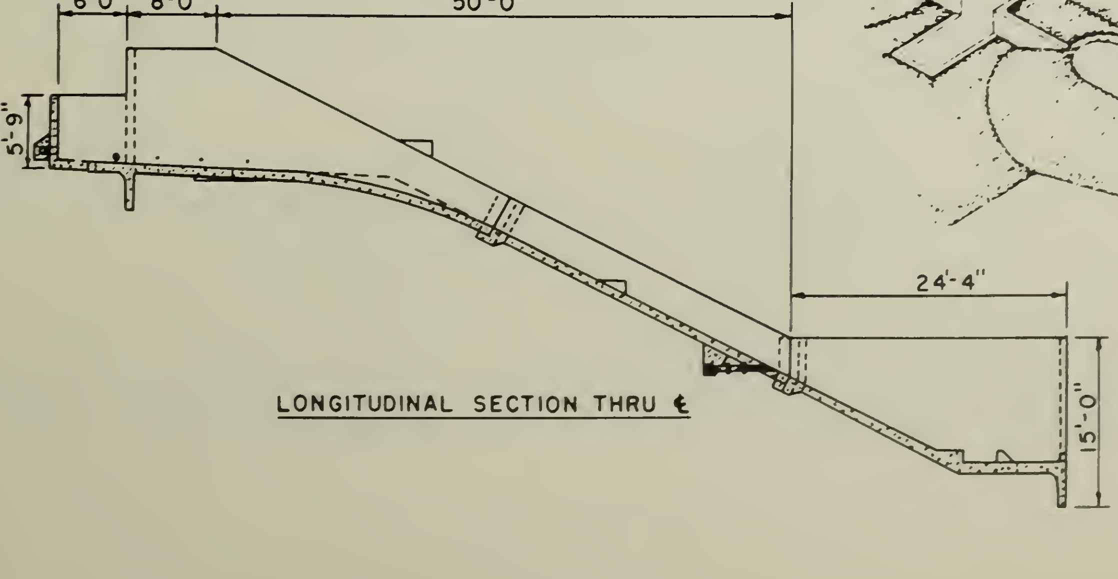
There is considerable danger of undermining of the structure by rodents, and, in poorly drained locations, seepage may threaten foundations.



Chute Spillway

SS-5





LONGITUDINAL SECTION THRU ℄

SOD CHUTE SPILLWAY

Description

The sod chute may be defined as a steep, sodded section of a water course, constructed to conduct the design flow of water through it in the shortest distance at a safe velocity. When water flows from a water course to a chute with a steeper grade, a transition in flow takes place; that is, a decrease in depth of flow with an increase in velocity. Chute widths will usually be less than water course widths. Therefore, a transition section between the waterway and the chute is necessary.

Materials

Required vegetation may be established by transplanting sod, or if the water can be diverted around the section for sufficient time, it may be established by seeding.

Functional Use

1. Control overfalls or abrupt changes in the slope of a natural or constructed waterway.
2. At the lower end of water courses, to conduct water over an overfall into a natural channel.
3. To conduct water from the flat area next to a drainage ditch to the bottom of the ditch.

Adaptability

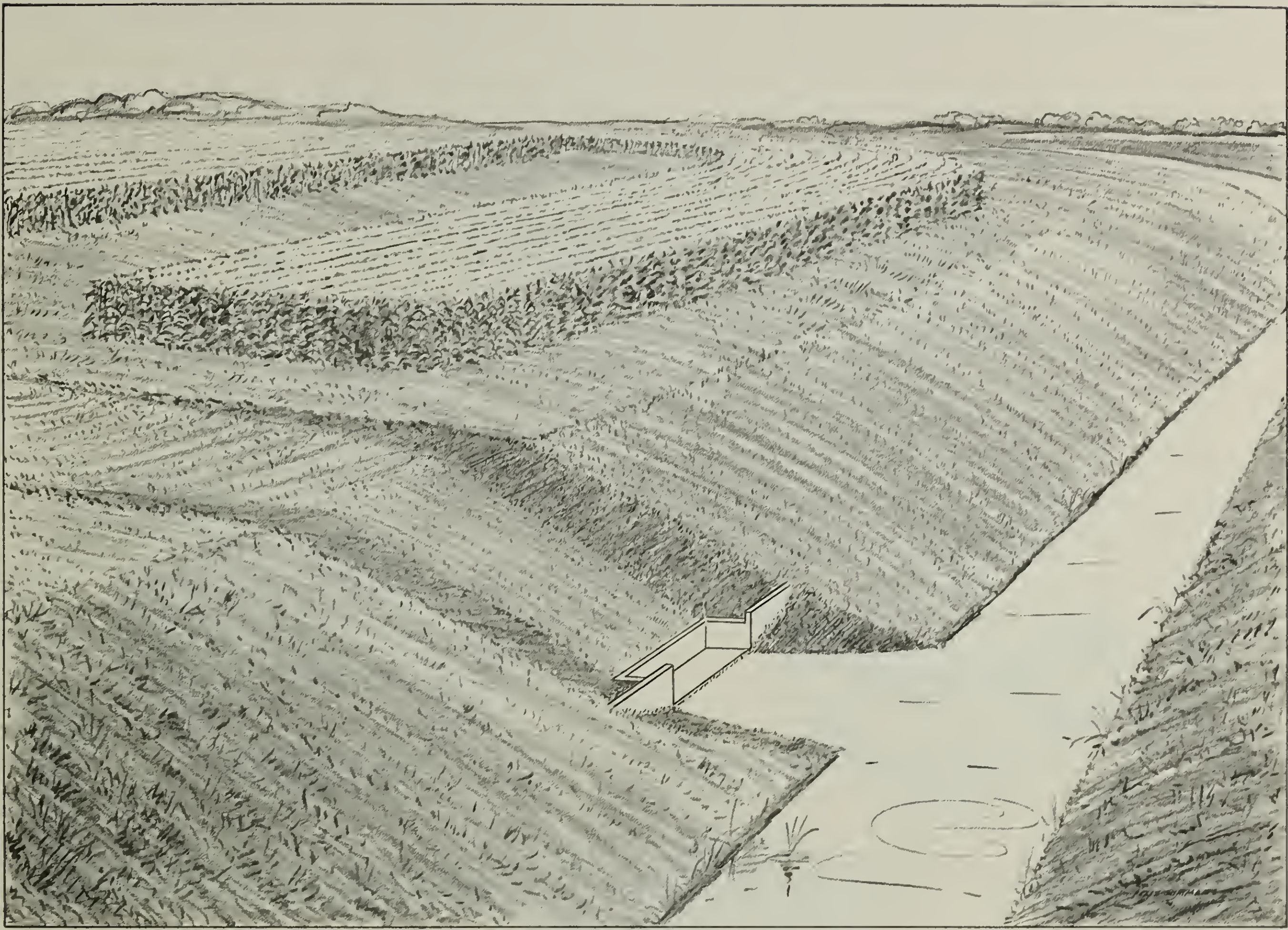
The sod chute is adapted to small watersheds and a site where good, dense sod can be developed and maintained. The watercourse below the chute must be stable. When the channel below the chute is narrow or conditions at the lower end of the chute may not be favorable to establish and maintain vegetation because of poor soil or rocky or wet conditions or siltation from adjacent ditches or streams, a toewall should be used. The toewall will raise the end of the sod chute above these unfavorable conditions and permit the maintenance of a good sod. The toewall is a small drop spillway with a headwall varying in height from 1 to 2 feet, depending upon site conditions.

Advantages

Low material costs and constructed with farm labor.

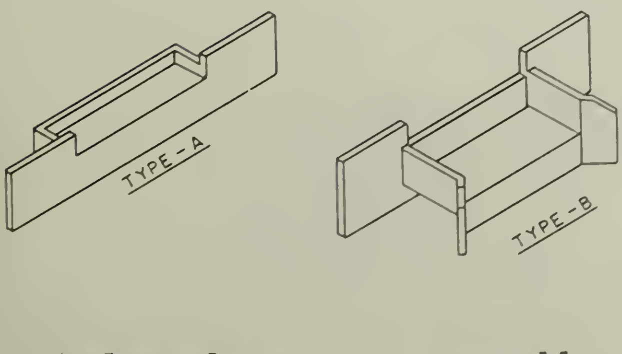
Limitations

It is limited to sites where the velocity of flow in the chute is low enough to maintain the sod cover. This generally means for small watersheds and low overfalls where there is no long, sustained flow.

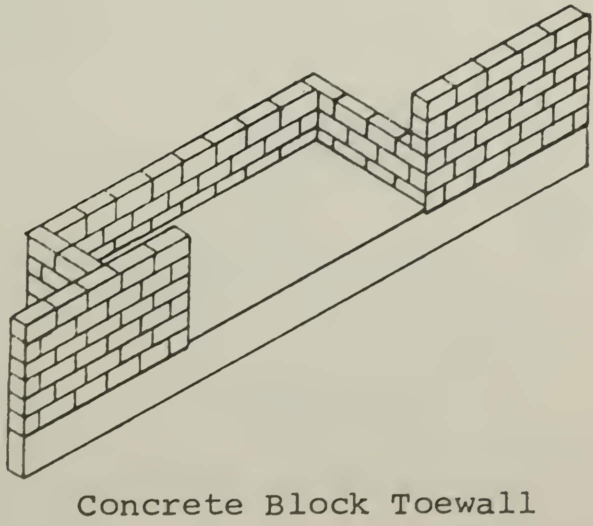


Sod chute and toe wall.

SS-22

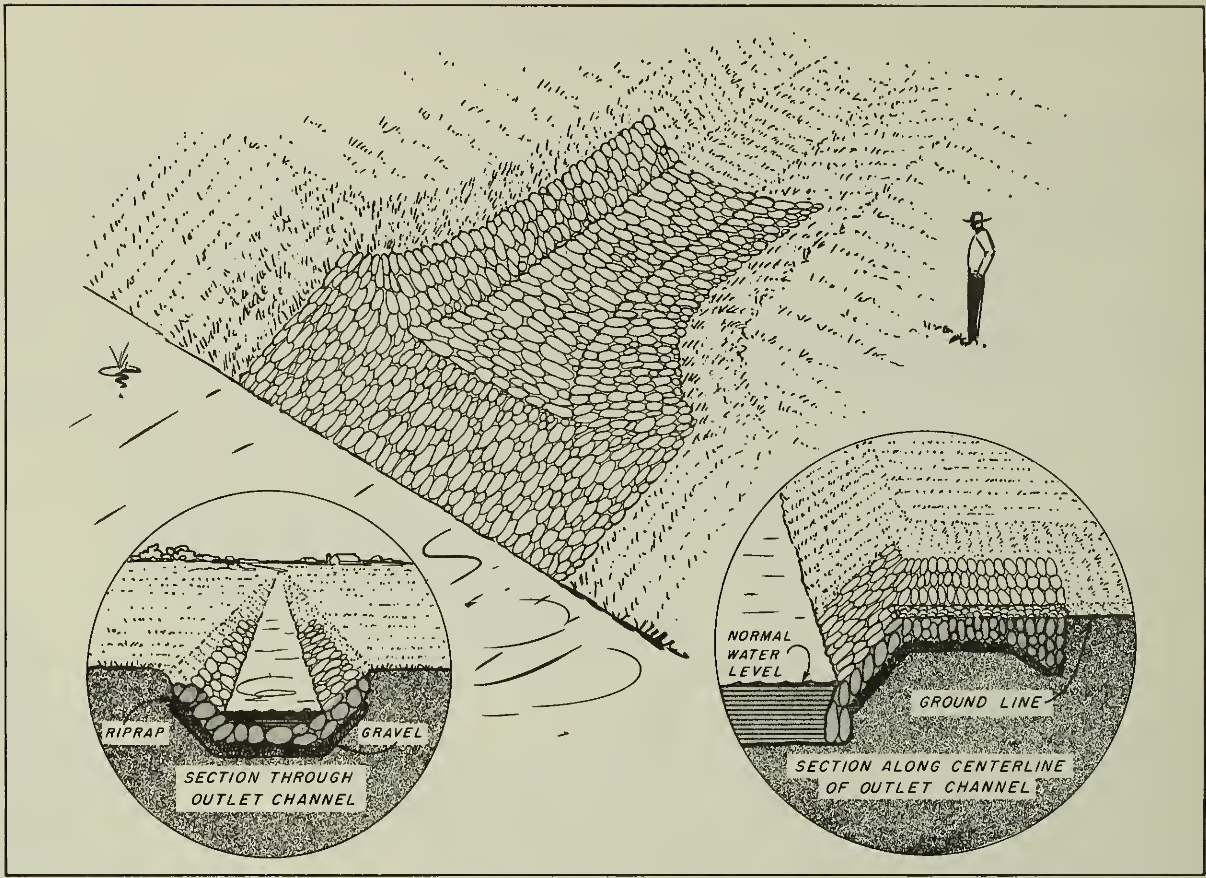


Reinforced Concrete Toewall



Concrete Block Toewall

ROCK LINED CHUTE & SPILLWAYS



RIPRAP CHUTE OUTLET STRUCTURE

Description

The riprap chute outlet structure is a rock-paved channel on a steep slope constructed to conduct the design flow of water through it in a short distance. It is similar to the sod chute but riprap is used for channel lining instead of sod.

Material

Riprap may consist of field or creekbed cobbles of varying sizes from a minimum of about 6 inches in their longest dimension to 18 inches, or a size that can be readily placed in the protective lining. Blasted rock in the same dimensions is suitable also. The base of the riprap should be protected by a 6-inch layer of creekbed sand and gravel to prevent leaching and uneven settlement of the protective lining. All rock should be placed with its longest dimension perpendicular to the line of flow and should be graded in a manner to eliminate any sizeable voids in the lining.

Functional Use

Same as for sod chutes except higher velocities can be maintained.

Adaptability

It is suitable for use for a wide range of discharge requirements. Utilization of available native material and simple construction make it adaptable for installation by farmers with the labor and equipment available to them.

Advantages

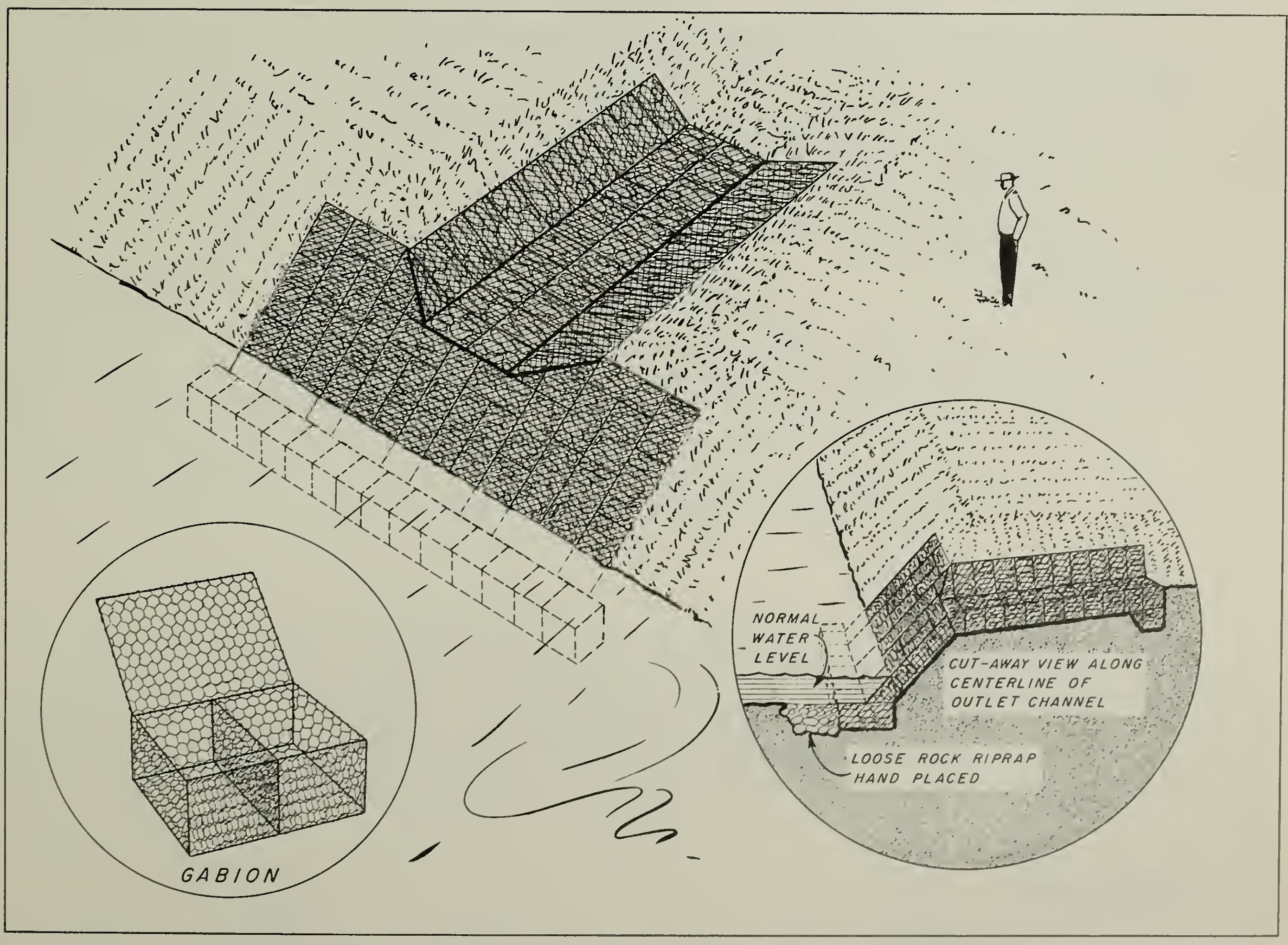
When properly constructed, it provides a more stable outlet than one constructed of sod or other vegetative protection. The opportunity to use native rock makes it less expensive than a pipe or concrete structure of comparable size. It is a permanent type facility requiring only limited maintenance.

Limitations

Its use is limited to areas where suitable and durable cobbles or rock are available for its construction. The cost of this type of outlet to some extent limits use to well developed farm and pasture lands. It requires careful adherence to the basic details of design in its construction to obtain satisfactory performance and stability.

GABION CHUTE

The gabion chute is similar to the riprap chute except that the rock is placed in wire baskets. The baskets are fitted to the subgrade and wired together to insure that they stay in place. It is a more costly structure and is generally restricted to important outlets requiring insurance of stability to protect expensive property or installations above them. It is particularly adaptable to unstable foundation conditions because of its ability to retain and adjust its general section to some displacement or settlement in its foundations. The opportunity to fill it with native rock and cobbles makes its cost favorable in comparison with reinforced concrete. It is anticipated that by the time the long-lasting wire gabion baskets deteriorate, the structure will be so well established and cemented together that it will remain indefinitely without the need for this extra protection.



Gabion Chute

DROP INLET SPILLWAY

Description

A drop inlet is a closed conduit designed to carry water under pressure from above an embankment to a lower elevation below. An embankment of earth or some other stable and relatively impervious material is required to direct the discharge through the spillway. Thus, the usual function of a drop inlet spillway is to convey excess runoff through or under an earth embankment without damage. Earth spillways around one or both ends of the embankment should always be used in conjunction with drop inlet spillways.

Materials

The riser of a drop inlet spillway may be of plain concrete, reinforced concrete, concrete blocks, or some type of pipe. The barrel section may be of reinforced concrete, shale, concrete, or clay tile, corrugated or smooth metal pipe having watertight joints.

Functional Uses

1. Outlets for farm ponds or reservoirs.
2. Erosion control structures and arresting gully heads.
3. At lower end of water disposal system.
4. Outlets for silt-retention reservoirs or settling basins.
5. Roadway structures.
6. Flood control structures.
7. Surface water inlet for drainage.

Adaptability

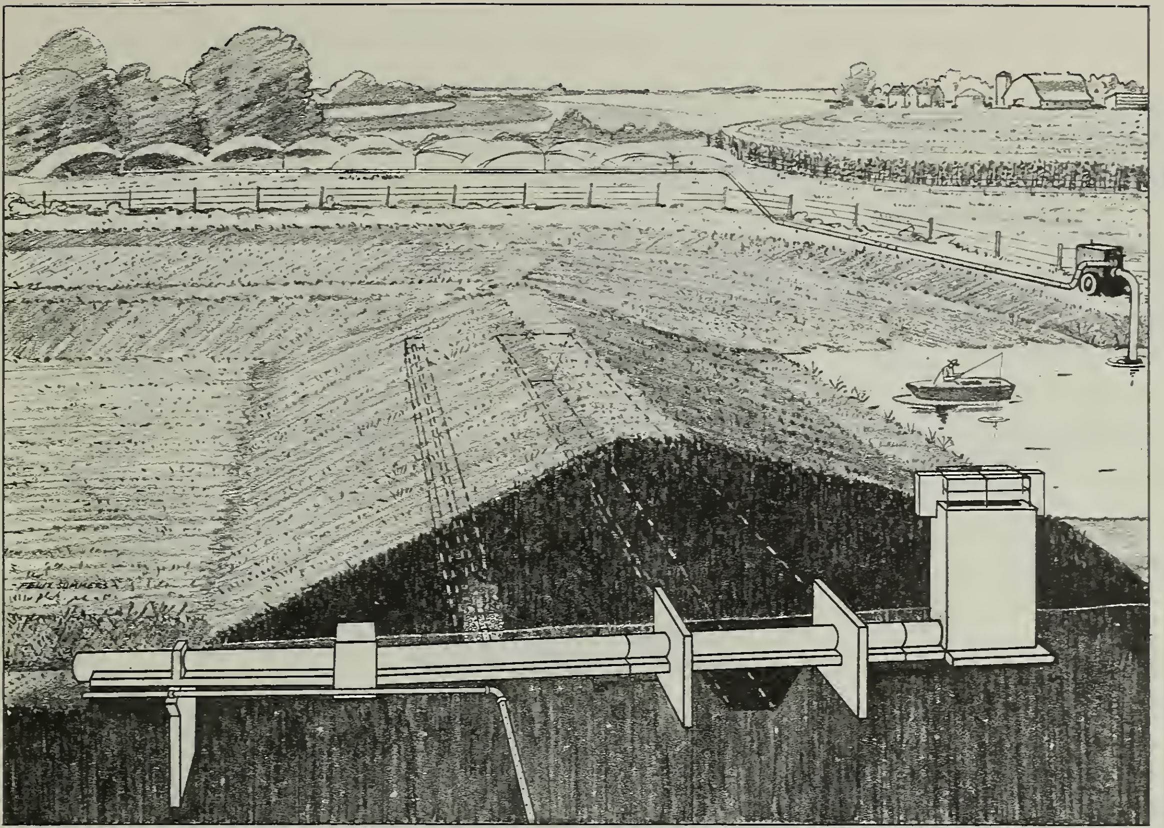
It is a very efficient structure in the control of relatively high head, usually above 10 feet. It is well adapted to sites providing an appreciable amount of temporary storage above the inlet. It may also be used in connection with relatively low heads, as in the case of a drop inlet on a road culvert, or passing surface water through a spoil bank along a drainage ditch.

Advantages

For high heads, it requires less material than a drop spillway under similar circumstances. Where an appreciable amount of temporary storage is available, the capacity of the structure can be materially reduced. Besides affecting a reduction in cost, this reduction of discharge results in a lower peak channel flow below, and can be a favorable factor in channel grade stabilization and flood control.

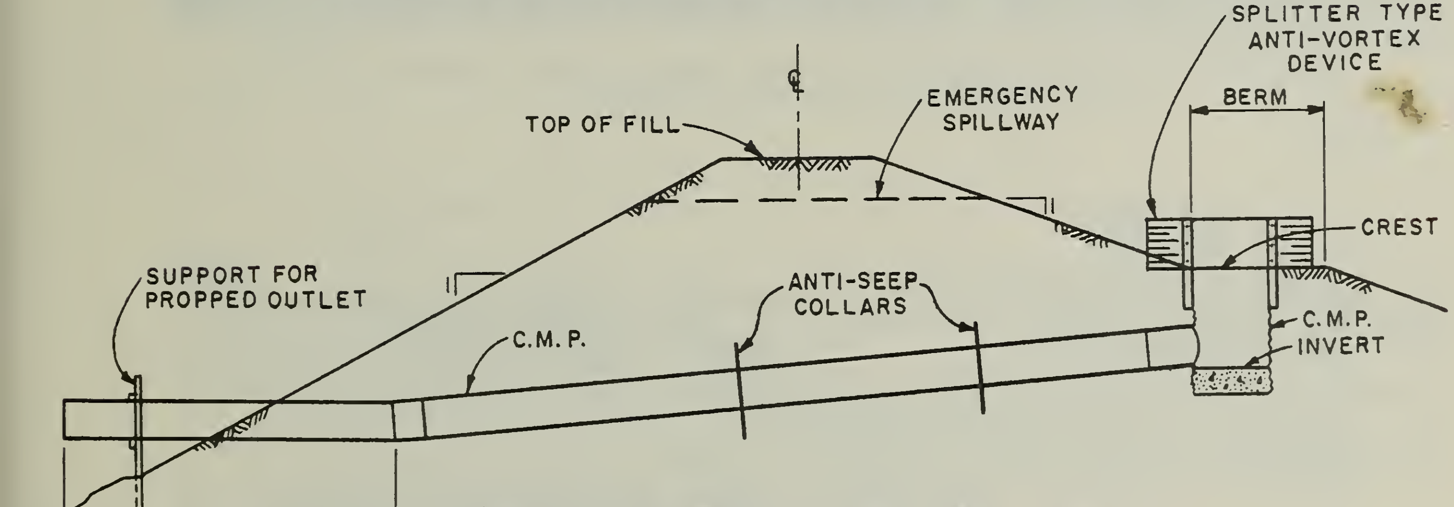
Limitations

Small drop inlets are subject to stoppage by debris. Effectiveness depends as much on the supporting earth fill material as on the structure itself. It is limited to locations where satisfactory earth embankments can be constructed.

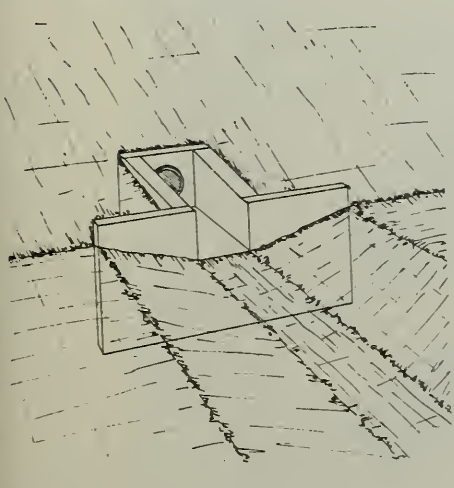


SS-2

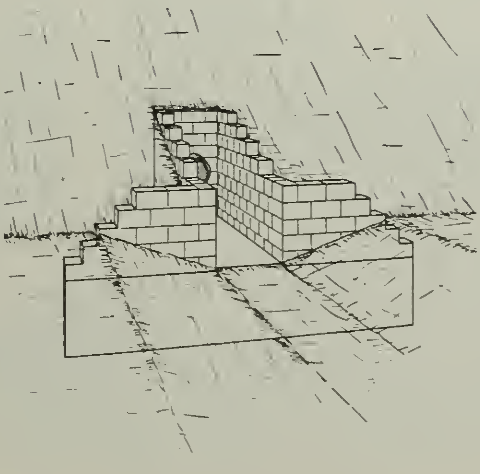
Earthfill dam with concrete drop-inlet and irrigation reservoir.



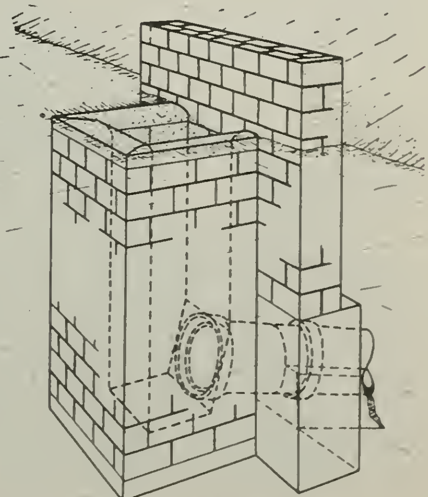
CORRUGATED METAL INLET AND CONDUIT



Reinforced Concrete

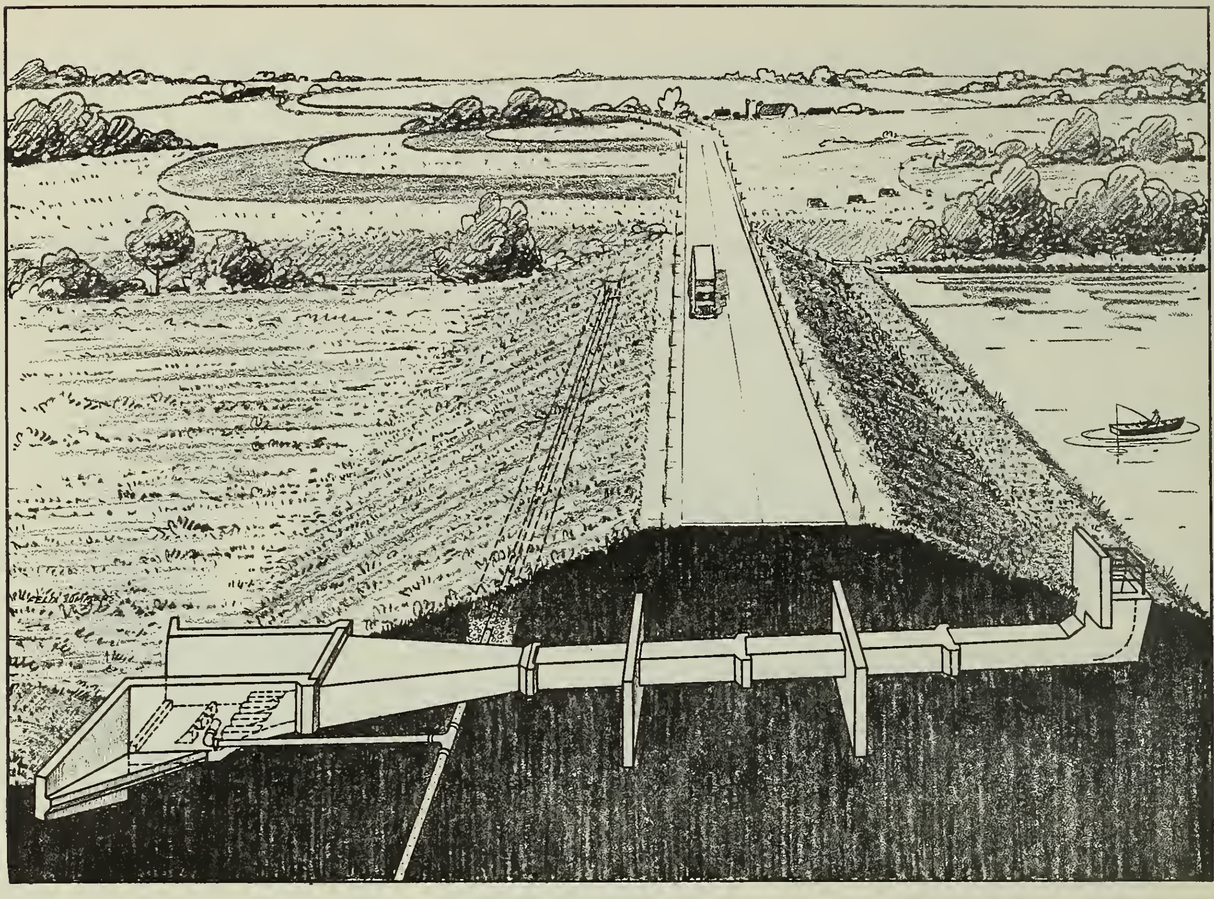


Concrete Block



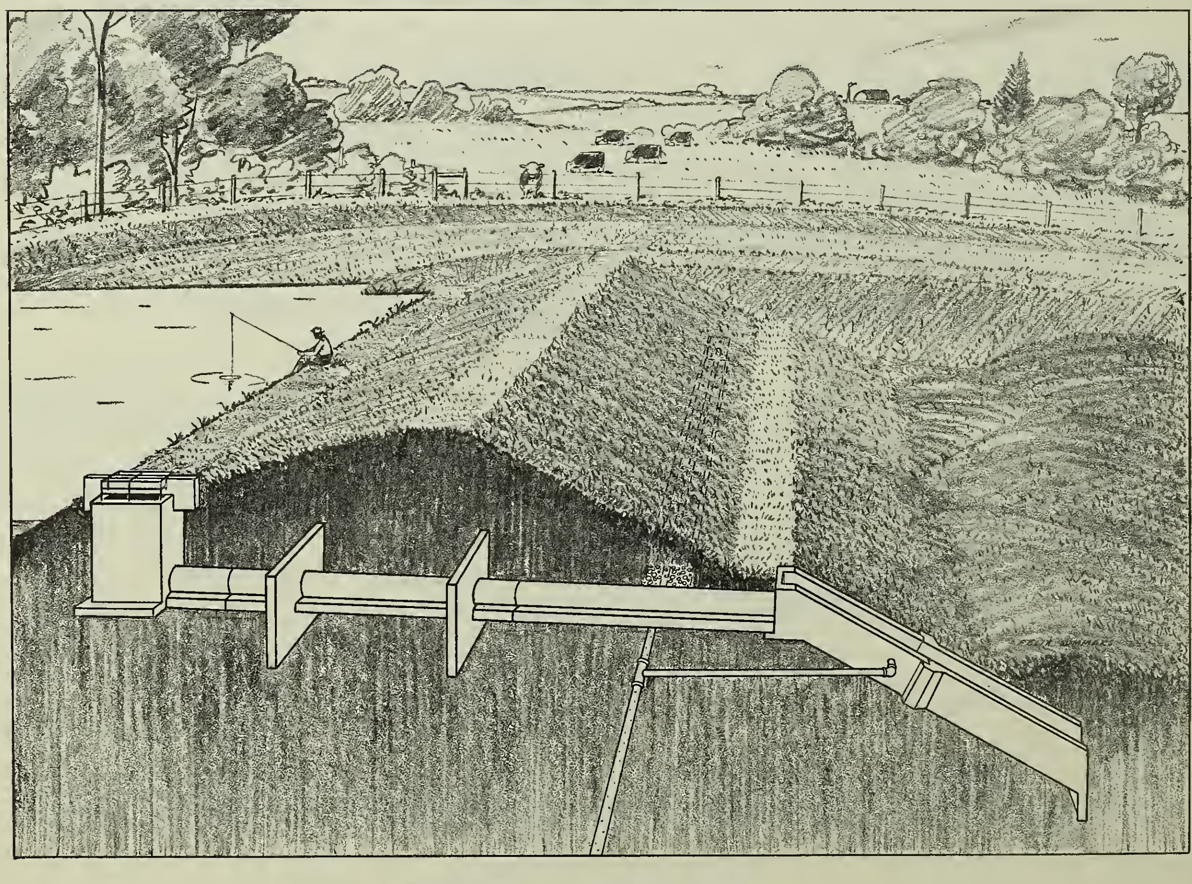
Concrete Block Inlet

SMALL PIPE OUTLETS



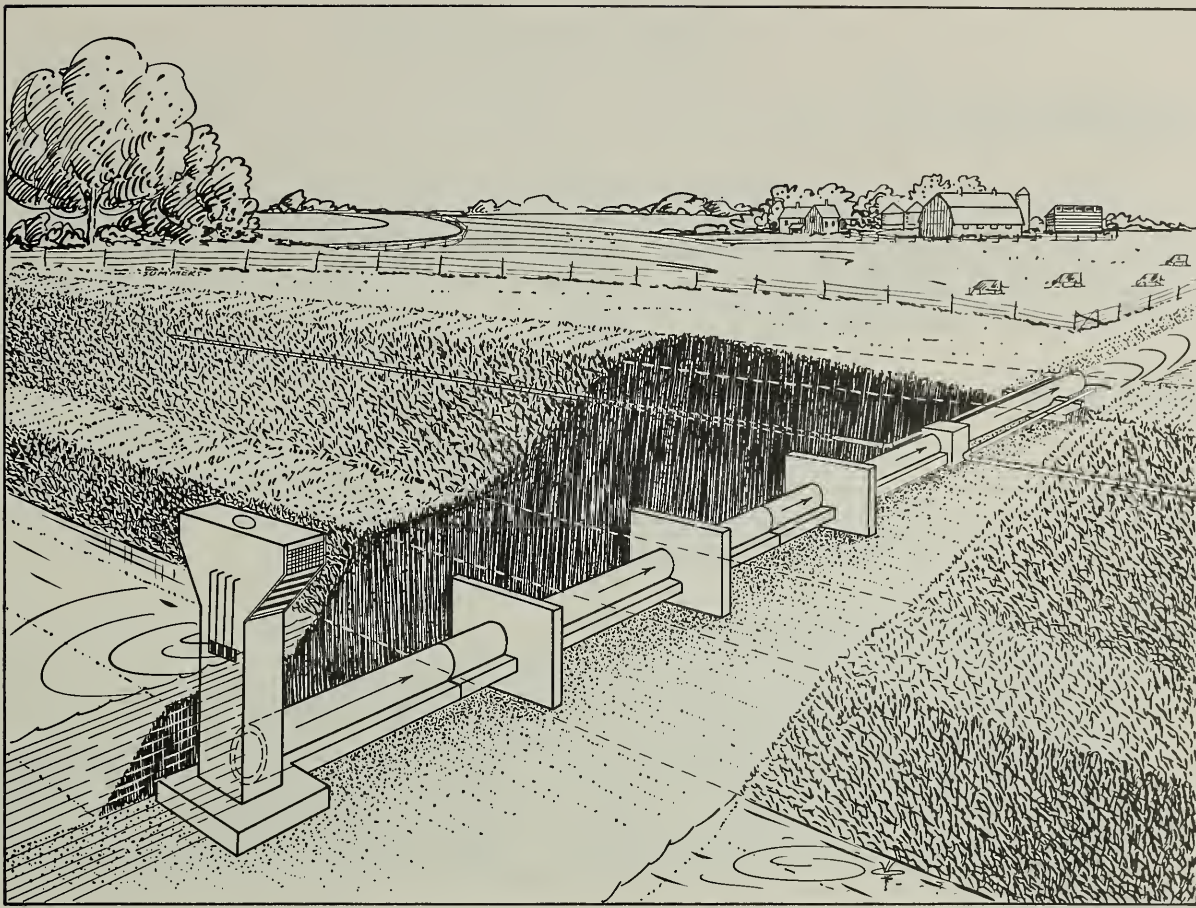
Monolithic drop-inlet on roadway and conservation pool with recreation and wildlife.

SS-8



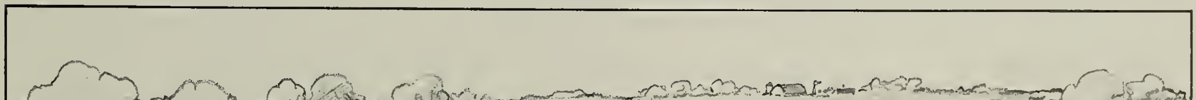
Drop-inlet with chute spillway.

SS-10



Reinforced concrete pipe with flat top inlet.

SS-14



Dry basin type earthfill dam with two-stage inlet.

SS-6

HOOD INLET SPILLWAY

Description

The hood inlet spillway consists of a pipe conduit with the inlet end formed by cutting the pipe at an angle. The long side of the cut is placed on top and figuratively forms a hood over the entrance. An anti-vortex wall or plate is located on the upper side of the pipe at the inlet.

Materials

The hood inlet spillway can be built of corrugated metal, welded steel, concrete, asbestos cement, and possibly other types of pipe. Corrugated metal is the most commonly used type of pipe, especially on small structures.

Functional Use

1. Farm ponds.
2. Grade control structures.
3. Water supply dams.
4. Retarding dams.
5. Along drainage ditches having a spoil bank.

Adaptability

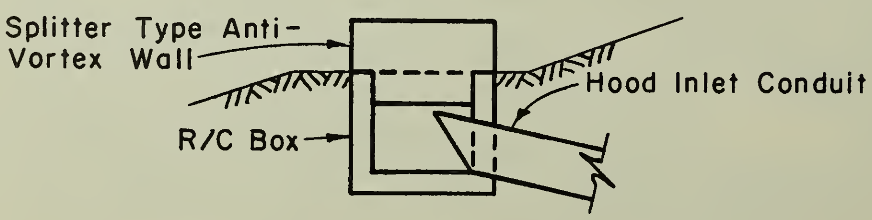
It is best adapted for use at those sites where the pipe can be installed in the original ground. Construction is complicated when the pipe is placed in the embankment.

Advantages

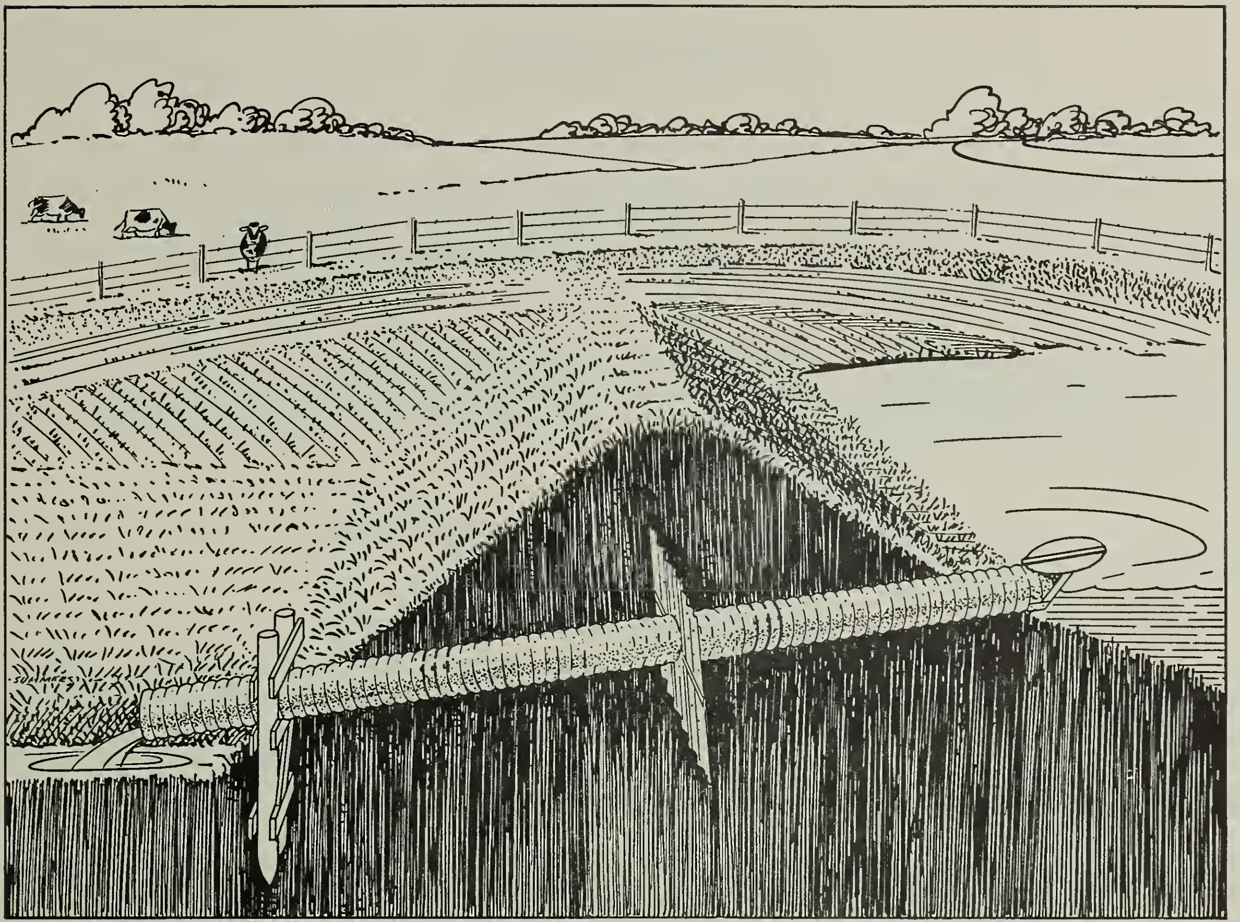
The hood inlet spillway will flow completely full no matter what the slope of the conduit may be if the length of the hood is properly selected and the head on the inlet is sufficient to submerge the inlet. As compared with the drop inlet, it has the advantage that no riser is required and there is less fill over the pipe. It is simple to fabricate and install and is comparatively low in cost.

Limitations

(1) For the same crest elevation, large diameter pipes (over 24 inches) require a greater depth of water over the inlet to obtain full pipe flow than with a straight drop inlet. (2) Where icing presents a problem. Both of these may be overcome with a box and hood combination.

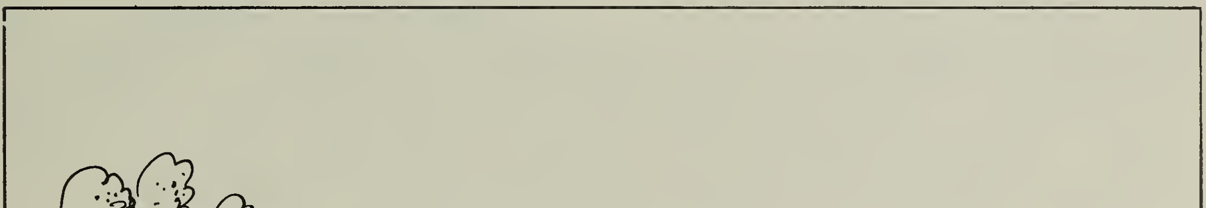


BOX AND HOOD COMBINATION



Metal pipe with hooded inlet.

SS-12



Reinforced concrete pipe with hooded inlet.

SS-15

EARTH SPILLWAY

Description

An earth spillway (side spillway) is an open channel. It is a passageway for floodwater to flow safely past an embankment from its reservoir to a point where its discharge will not damage the toe of the earth embankment.

The earth spillway is trapezoidal in cross section and must have erosion-resistant vegetation established on the channel bottom and side slopes. If the spillway is excavated through rock, it may be rectangular.

An earth spillway consists of an inlet channel, a control section and an exit channel.

The inlet channel is defined as that part of the spillway upstream from the control section. The exit channel is that part of the spillway downstream from the control section. The control section is that section of the spillway between the inlet channel and the exit channel. At the control section, the discharge capacity can be determined.

Functional Use

The earth spillway may serve as the principal spillway, auxiliary spillway, or emergency spillway. It is generally used in conjunction with some type of mechanical spillway.

Principal Spillway - In this case the earth spillway is designed to carry most or all of the discharge. It is best to supplement it with a mechanical spillway (trickle tube) that will convey small amounts of runoff and keep the vegetated earth spillway free of prolonged flows which tend to prevent vigorous growth of vegetation.

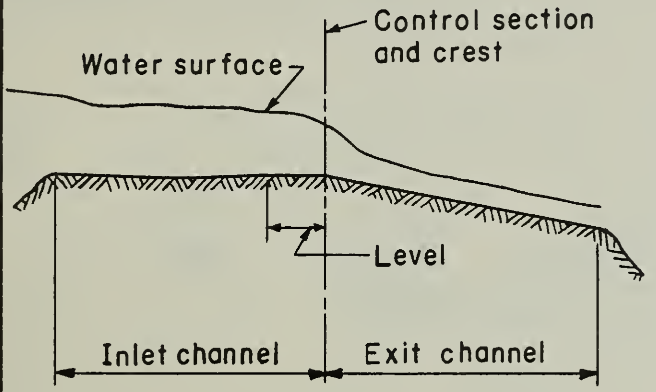
Emergency Spillway - It assists the mechanical principal spillway in conveying large flood flows safely past an earth dam embankment.

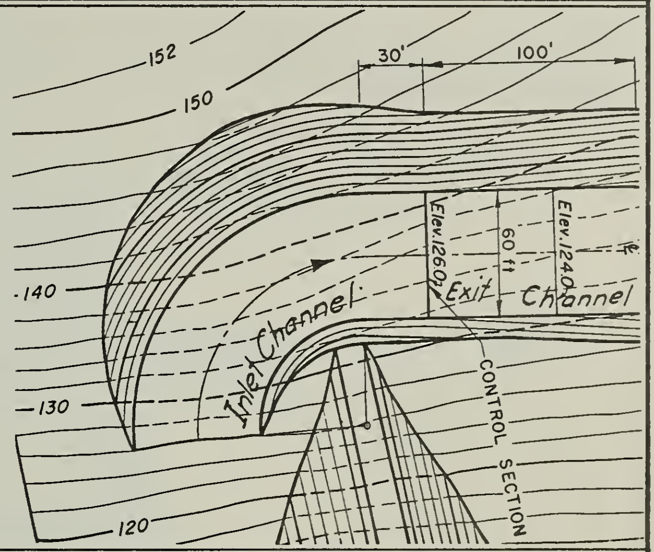
Layout

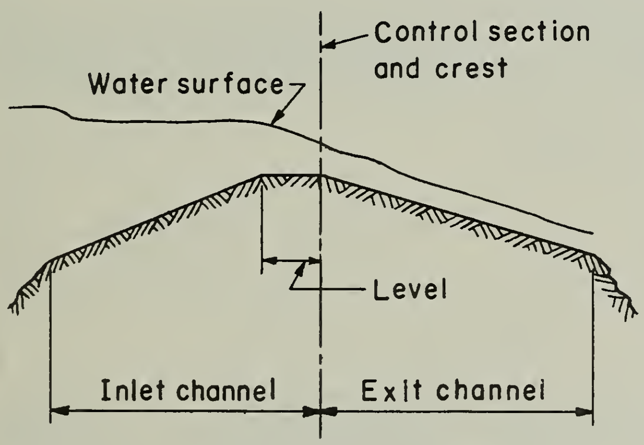
Earth spillways are usually located in undisturbed earth in the abutments at one or both ends of an earth embankment or over a topographic saddle at some point on the periphery of the reservoir. The channel should be excavated into undisturbed earth or rock, and the water surface under maximum possible discharge should be confined by undisturbed earth or rock or carefully constructed and compacted levees of safe proportions. In no case should the water surface be permitted against loose, uncompacted fill. Typical layouts are shown on opposite page. Selection of layout depends upon site conditions and hydraulic design considerations.

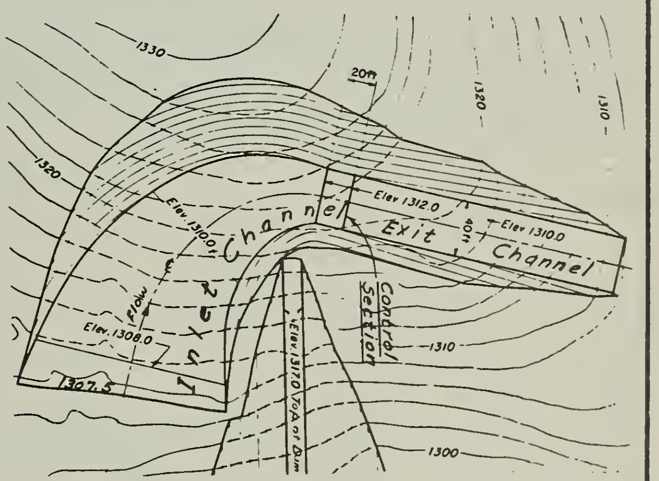
TYPICAL PROFILES AND PLANS-EARTH SPILLWAY

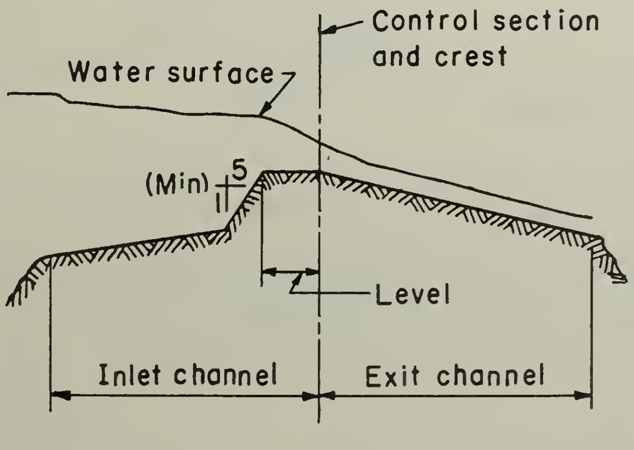
PROFILE ALONG CENTERLINE	LAYOUT AND GRADING PLAN

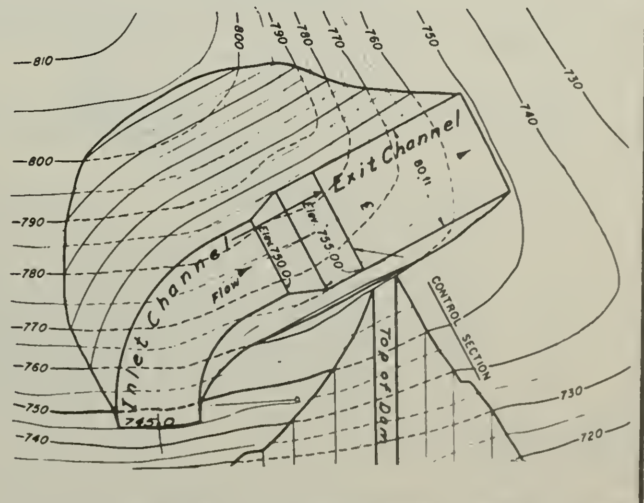




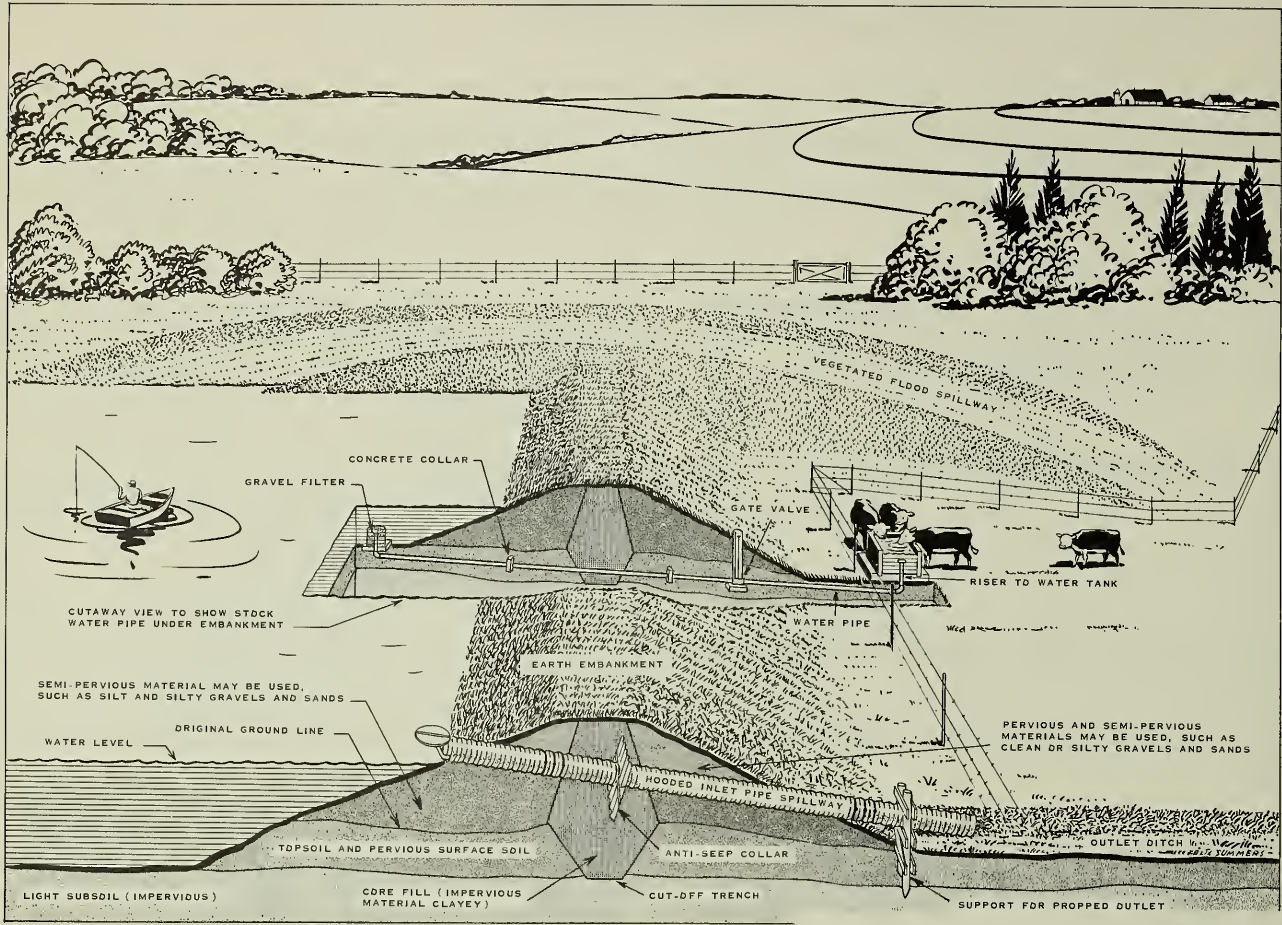








EARTH DAM EMBANKMENTS



Embankment Pond SS-23

Description

The earth embankment, because its construction involves utilization of natural, unprocessed materials, is the most common type of dam. As its name implies, it is constructed of soil borrowed in the vicinity of the dam site. Adequate compaction of the fill as it is being placed is a "must". Sound engineering procedures must be followed in both the design and construction, such as: (a) Thorough preconstruction investigations of foundation conditions and materials of construction; (b) Application of engineering skill and techniques to design; (c) Carefully planned and controlled methods of construction.

Functional Use

Earth embankment dams with necessary spillways may be constructed to serve one or several intended purposes.

1. Retention dam to permanently impound water such as a farm pond, irrigation reservoir, municipal water supply, or recreation lake.
2. Detention or dry dam where release rates are controlled to eventually discharge all or part of the impounded water.
3. Grade stabilization, sediment, and erosion control.

Adaptability

Adapted to any gully or valley site where the banks are high enough to permit the construction of an earth embankment to provide the necessary protection or facilities.

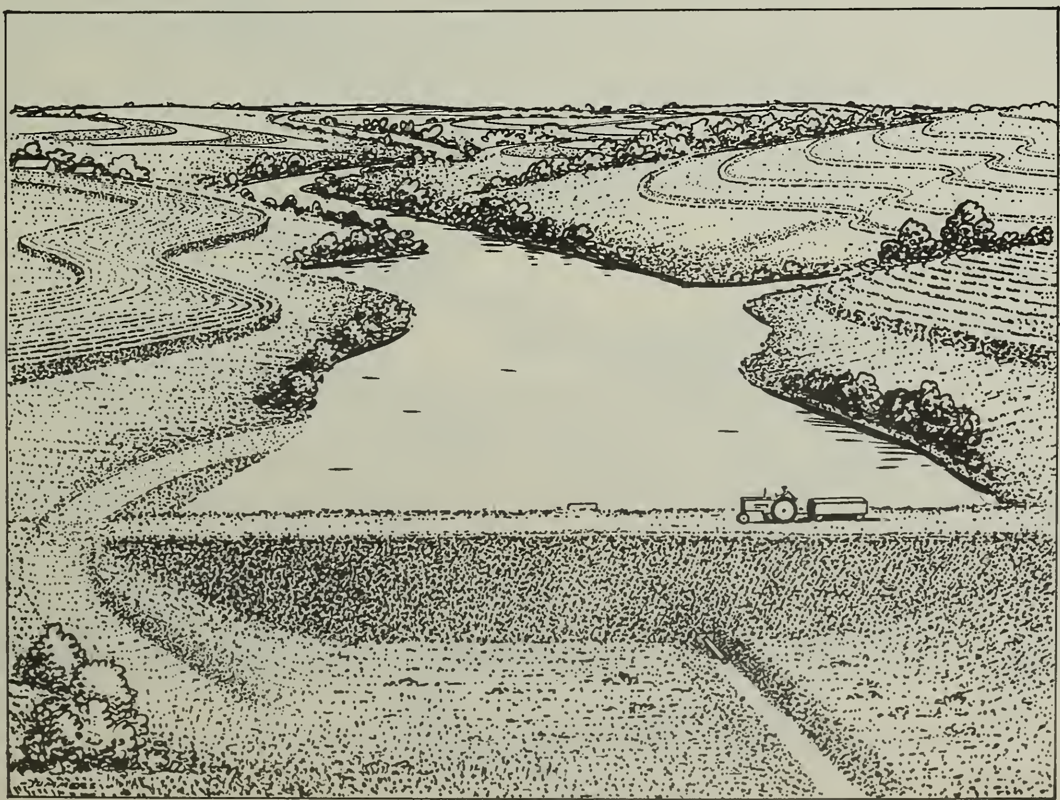
RESERVOIRS

A reservoir is a place where water is collected and stored, generally in large quantities. The average farm pond in the strict sense is a reservoir. However, due to its size, it is seldom called a reservoir. The use of the stored water may have a bearing on whether it is called a farm pond or reservoir, such as an irrigation reservoir or a municipal water supply reservoir. The general types of reservoirs are:

1. Storage reservoirs. In this case, water is impounded and stored in large quantities for future use in irrigation, municipal water supply and recreation for community use.

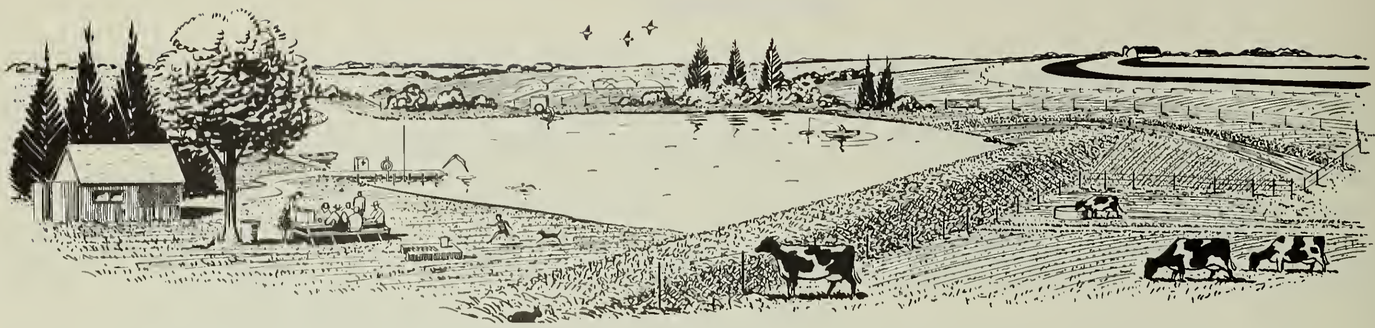
2. Retarding reservoirs. Retarding reservoirs are ordinarily constructed to reduce the peak flows and resulting damage downstream from the dam site. Where the need exists, sediment storage can also be incorporated in the design of the floodwater retarding reservoir in order to reduce or eliminate sediment damage occurring downstream from the dam location.

3. Multiple purpose reservoirs. Frequently, two or more purposes can be incorporated in a single reservoir. If the site permits, a given reservoir can be designed to permanently store damaging sediment to store water for one or more of the uses described above, and to store floodwater temporarily so as to alleviate downstream floodwater damages. Also, the permanent pool levels in floodwater retarding structures are often set so that they stabilize gullies which extend upstream or laterally from the reservoir site.



Floodwater retarding and storage reservoir

FARM POND

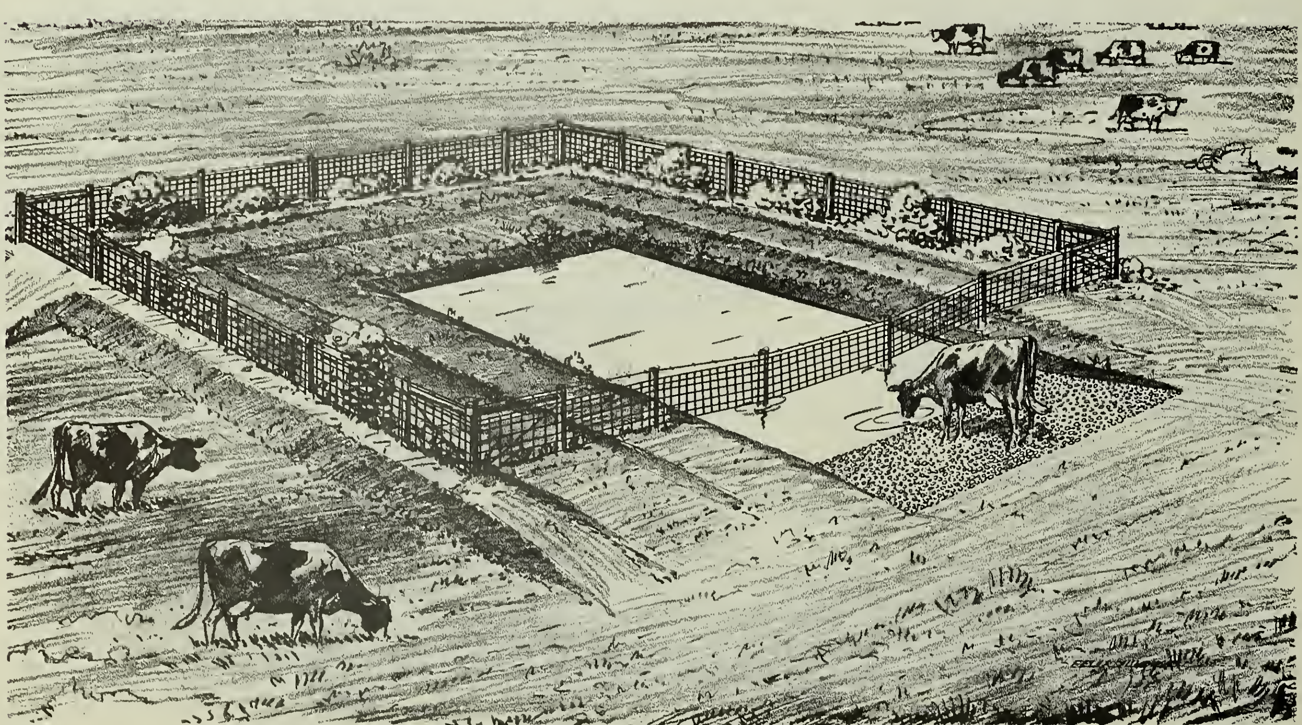


The farm pond is an artificially constructed water collection and storage facility for uses listed on the opposite page.

1. The embankment pond is formed by constructing an earth embankment or dam across the gully or small valley at a narrow point. It is generally the easiest and least expensive pond for the amount of water stored and earth moved.

2. The hillside pond is constructed on sloping land by excavating most of the pond area. The excavated material is placed on the downhill side to form an embankment. This type is limited to very small ponds.

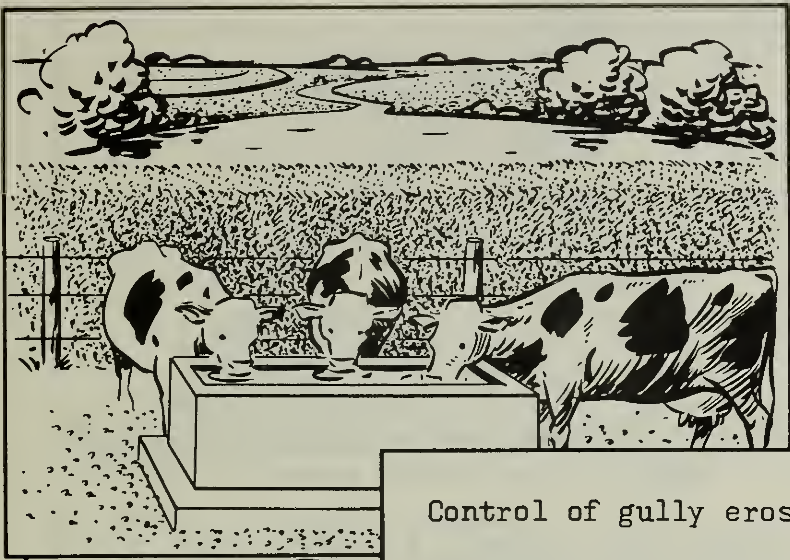
3. The pit pond is dug in flat land areas where a water supply can be obtained from underground seepage, springs, or tile lines. In some cases, a small amount of runoff may be diverted into the pond. The pit pond, of necessity, is small because most or all of the pond area must be dug out.

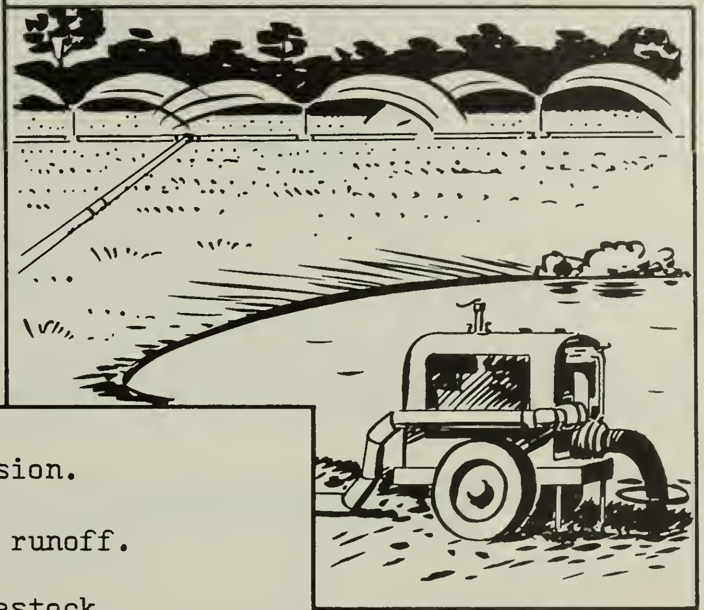


Developing springs or seeps for livestock watering.

PIT POND

A Farm Pond Has Many Uses!





Control of gully erosion.

Retarding floodwater runoff.

Water supply for livestock.

Water for irrigation.

Ponds for fish.

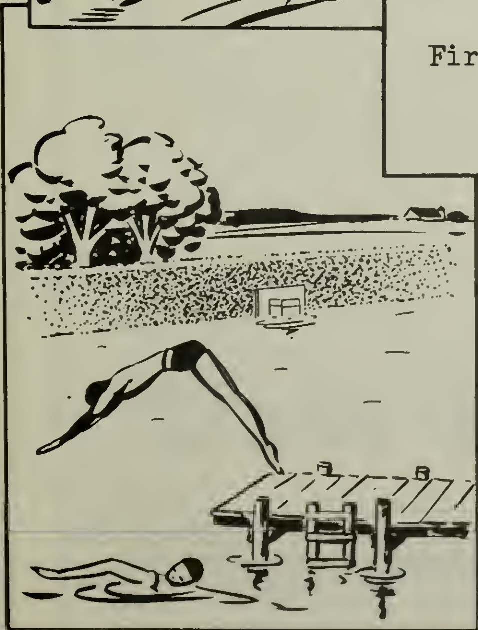
Ponds for wildlife.

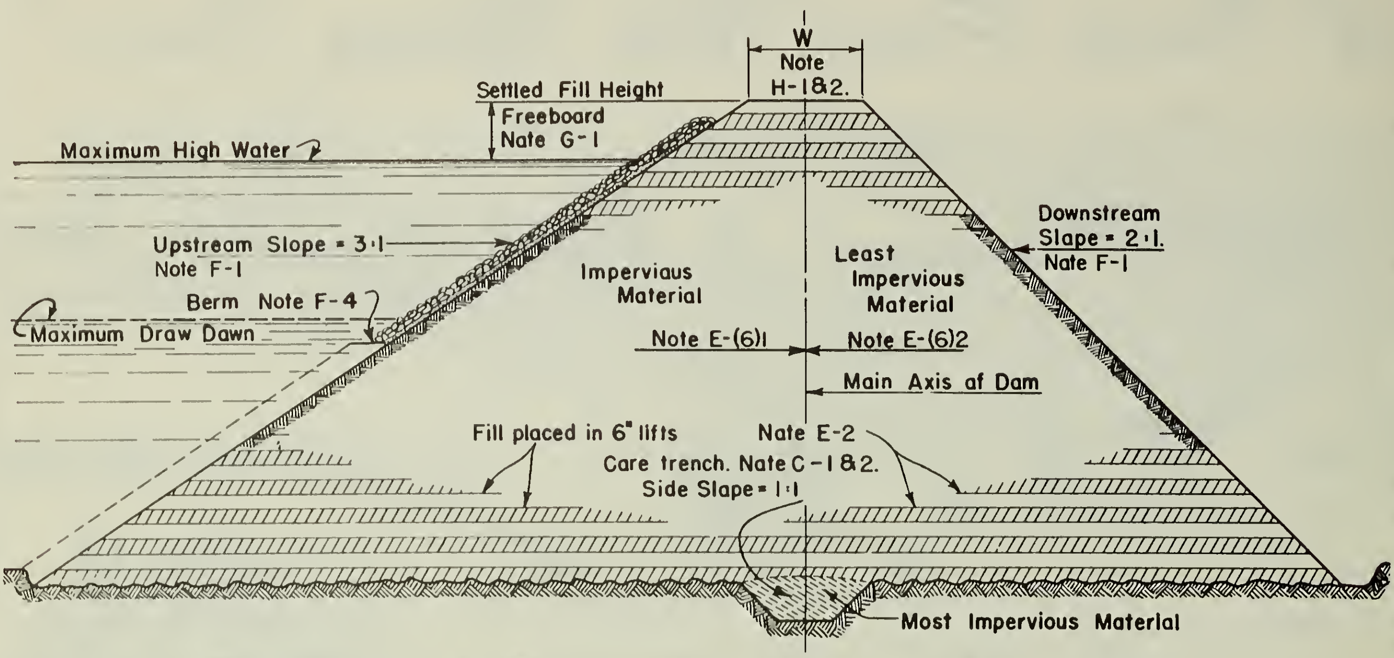
Ponds for recreation and family fun.

Water for orchard spray.

Water for home use.

Fire protection.





EMBANKMENT CROSS SECTION

SCALES: VERT. 1"=10'-HOR. 1"=20'

DESIGN DATA FOR SMALL EARTH FILL DAM

(MAXIMUM FILL HEIGHT-25 FEET)

EARTH FILL SPECIFICATIONS

A. GENERAL - The work covered by this specification consists of furnishing all labor and equipment and performing all excavation and other operations in connection with the construction of the earth fill as shown on the plans or as directed by the technician.

B. PREPARATION OF FILL SITE AND BORROW PIT.
1. Remove all stumps, trash, brush, sod, large roots, perishable material, and loose and open soil from the staked site.
2. Roughen ground surface by scarifying or plowing to provide bond between the foundation and earth fill. Topsoil material shall be stripped from the foundation and borrow areas and deposited in storage piles.
3. Overhanging banks, pits, or holes shall be sloped 1:1 to provide bond with the fill.
4. Springs encountered in preparing the site shall be drained or sealed.

C. CORE TRENCH CONSTRUCTION.
1. Excavate a trench in the foundation along the transverse axis and extending the full length of the embankment. Excavation of the core trench in the abutments should be made where shown on the plans or directed by technician. Excavate the trench to a more impervious material than that immediately underlying the dam or to the depth and dimensions as shown on the plans. The core trench shall have a minimum depth of 3'-0", and bottom width of 4'-0" with 1:1 side slopes.
2. Backfill with the most impervious material available at the site, with moisture content sufficient to secure compaction.

D. PIPES FOR STOCK WATERING.
1. Pipe and appurtenances for the water supply system should be placed according to the plans or as directed by the technician. The pipe shall be placed on a solid foundation with a minimum of two - 2'-0" x 2'-0" cutoff collars.

Rev. 12-1-60
Rev. 7-20-56

GENERAL SPECIFICATIONS FOR SMALL EARTH FILL DAMS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
L.G. SIGNELL & G.W. FOSTER	10-9-40	Title
Drawn G.E. WEVER	10-9-40	Title
Traced		
Checked G.W. FOSTER	10-9-40 4-20-49	Sheet No. ___ of ___ / Drawing No. 3-L-7261

CONSTRUCTION OF FILL.

1. Earth fill material shall not contain any appreciable concentration of vegetation, roots, large rocks, frozen soil, or other foreign substance. Moisture content shall be sufficient to secure compaction. When kneaded in the hand, the soil should just form a ball which does not readily separate to meet the requirements for adequate moisture content.
2. The fill shall be placed in approximately 6-inch layers and extend over the full width of the dam. Each layer shall be compacted by the operation of tractors, earth-moving equipment and/or rolled with flat or sheepsfoot rollers. If the moisture content of the fill is deficient, sprinkle with water after compaction and prior to placing the next layer.
3. Backfill adjacent to the spillway shall be placed in 6-inch layers and tamped by hand. Heavy equipment shall not be driven over the spillway until after a minimum of 3 feet of compacted fill has been placed above the top of the conduit.
4. Templates should be used to obtain a uniform slope from top to bottom.
5. Fill shall not be placed on frozen soil. If the surface of the fill becomes saturated or slick, it shall be allowed to dry and be thoroughly scarified before placing additional layers of fill.
6. At sites where there is a limited amount of the most impervious fill material, (1) place this material in the core trench and the upstream half of the embankment, and (2) place the least impervious material in the downstream part of the embankment.
7. The topsoil material saved in the site preparation shall be placed as a topdressing on the surface of the emergency spillways, embankments, and borrow areas. It shall be evenly spread to a thickness as directed by the technician.

SLOPES AND BERMS.

1. As a general rule, fill slopes shall not be less than 2:1 on the downstream side and 3:1 on the upstream side.
2. A berm with a minimum width of 5 feet shall be placed at the crest elevation of all principal spillways on the upstream side of the dam. This berm shall usually extend across the entire length of the fill. On small structures, the berm may be semi-circular and located only at the immediate vicinity of the inlet, using a minimum radius of 8'-0" about the center of the downstream face of the riser.
3. Downstream slope and top of dam shall be seeded to provide protective cover. Soil amendments, seeding mixtures, rates of seeding, and mulching shall be specified by the work unit conservationist. Solid sodding may be used on all or parts of the embankment when necessary to provide immediate protection.
4. Upstream slope shall be protected against wave action and surface runoff by sod, aquatic plants, reed canary grass, and/or riprapping, depending upon conditions encountered. When riprap is used, a berm 4'-0" wide shall serve as a base, located below the effect of wave action at maximum drawdown considering water usage, evaporation and seepage.
5. At the junction of fill slopes with the natural banks, gutters shall be shaped and sodded to carry surface runoff, or water can be diverted out of the gutter to discharge on suitable sod.
6. Foundation and abutment of the fill site should be investigated to determine drainage needs.

FREEBOARD.

1. Freeboard may be defined as the difference in elevation provided between maximum high water and the top of the settled fill.
   a. A factor to consider is wave action. If the axis of the pond is in direct line with the prevailing winds, the height "f_w" to allow for wave action may be estimated by the formula "$f_w = 0.04 \sqrt{D}$," where "D" is the length of pond exposure in feet.
   b. In no case shall the design freeboard be less than 1'-0".

WIDTH OF TOP OF DAM.

1. The minimum top width of dam shall be 8'-0" up to fill height of 15 feet. When fill height exceeds 15 feet, the minimum top width shall be increased 1'-0" for each 5'-0" additional height of fill.
2. When top of dam is used for a farm road, the minimum width shall be 12'-0". When top of dam is used for a public road, the specifications of the responsible road authorities shall govern.

MAINTENANCE.

1. Dam and structure shall be inspected periodically and necessary maintenance performed.
2. Protect dam and structure against damage by livestock.
3. Brush or trees shall not be allowed to grow on the dam, or within 50 feet of any part of it.
4. Protect dam against burrowing rodents.

WATER CONTROL STRUCTURES

Description

Water level control structures are designed to regulate and maintain water in ditches for water table control or for flooding land surfaces. The control is accomplished by use of gates or stop logs that can be fitted into several types of structures.

Uses

1. Control drainage. To maintain a high water table consistent with the crop by reducing the depth of normal drainage. Also to control the water table in peat and muck to reduce subsidence.

2. Sub-irrigation. Sub-irrigation is similar to controlled drainage and differs in that water is supplied from an outside source to maintain a high water table throughout the growing season. With controlled drainage, the water table generally drops during the hot, dry weather toward the end of the season.

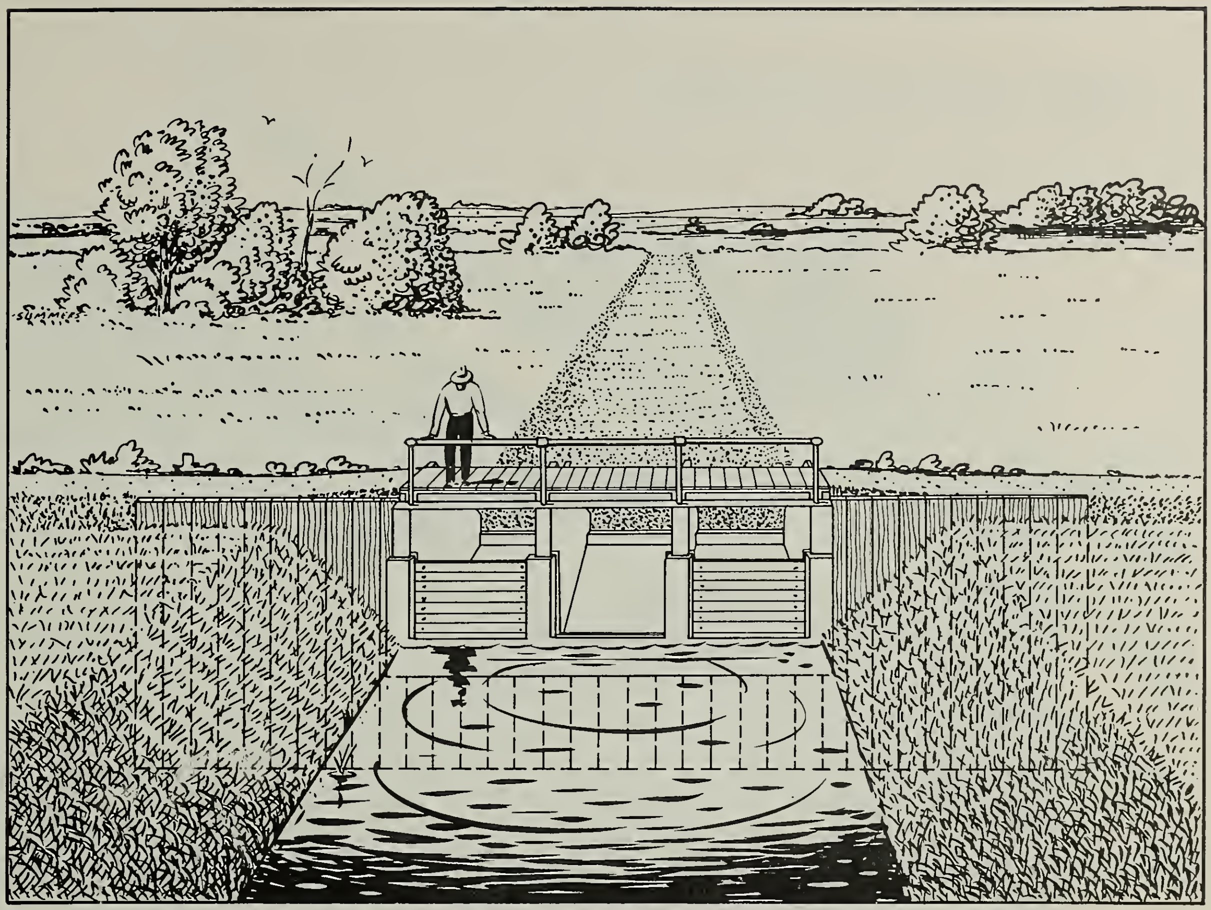
3. Flooding. Flooding of the land surface is necessary in the production of some crops such as cranberries and rice.

Types of Structures

1. Drop spillways with gates or stop logs. The drop spillway is generally constructed of reinforced concrete, timber sheet piling or corrugated steel sheet piling. Reinforced concrete is the most permanent and also the most expensive. It has the longest life. It can be adapted to a bridge crossing and the height and width can be varied to accommodate any ordinary drainage channel. Sheet piling spillways will require the use of special equipment to drive the piling or jet it into place. Creosote plank will give reasonably long life. In any event, only first-class lumber should be used. Steel sheet piling will make a permanent structure if properly installed and protected, with a cost similar to reinforced concrete.

2. Box inlet on culvert with gate or stop logs. This structure combines a roadway with a water control structure. It usually can be built cheaper than separate construction of a dam and a farm crossing. The culvert may be concrete, corrugated metal pipe or timber conduit. The box inlet section is generally made of reinforced concrete, timber, or a half section of metal pipe.

3. Open flume. This is similar to a culvert with the top side open and stop logs or gate installed at the upstream end for controlling the water level. It is generally constructed of concrete or timber.



Straight drop spillway with stop logs.

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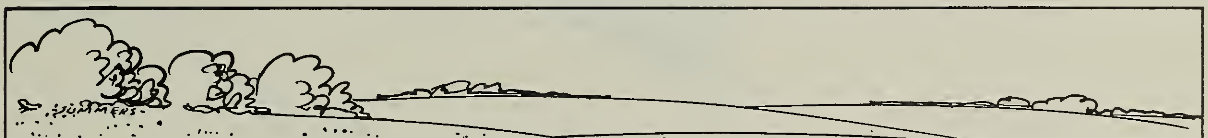

Straight drop spillway with gate.

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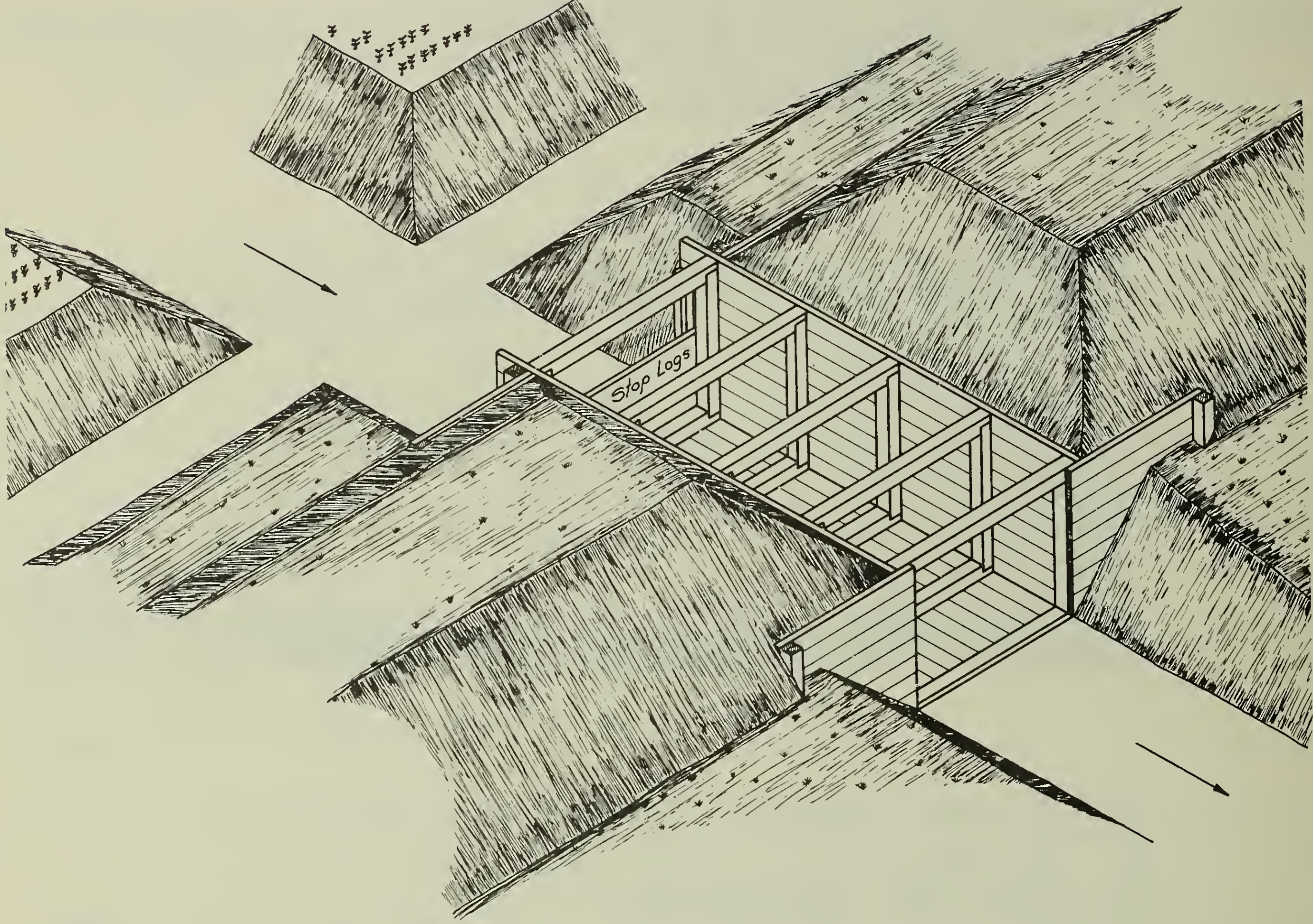
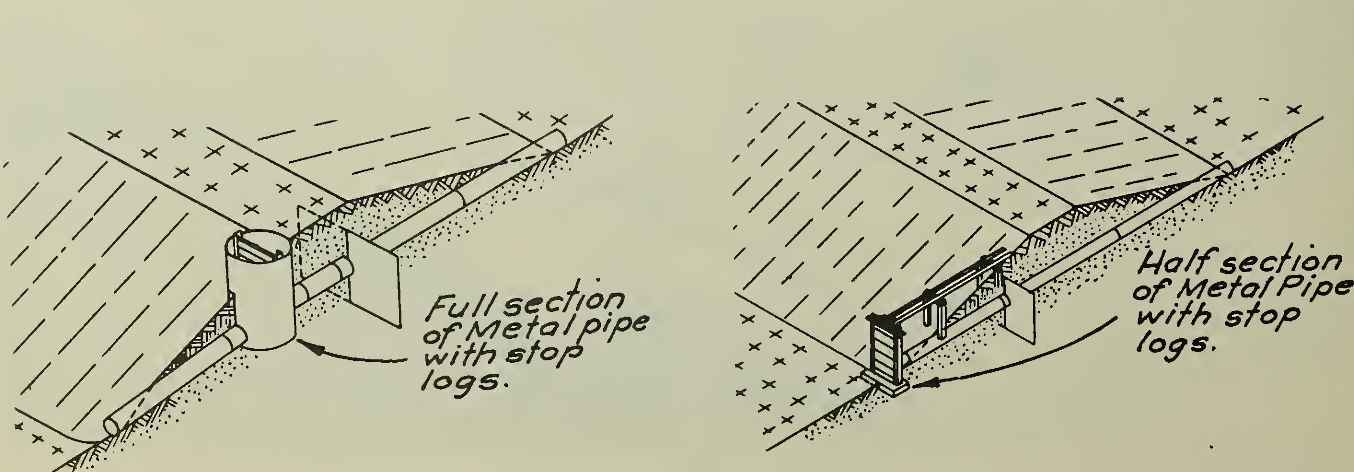
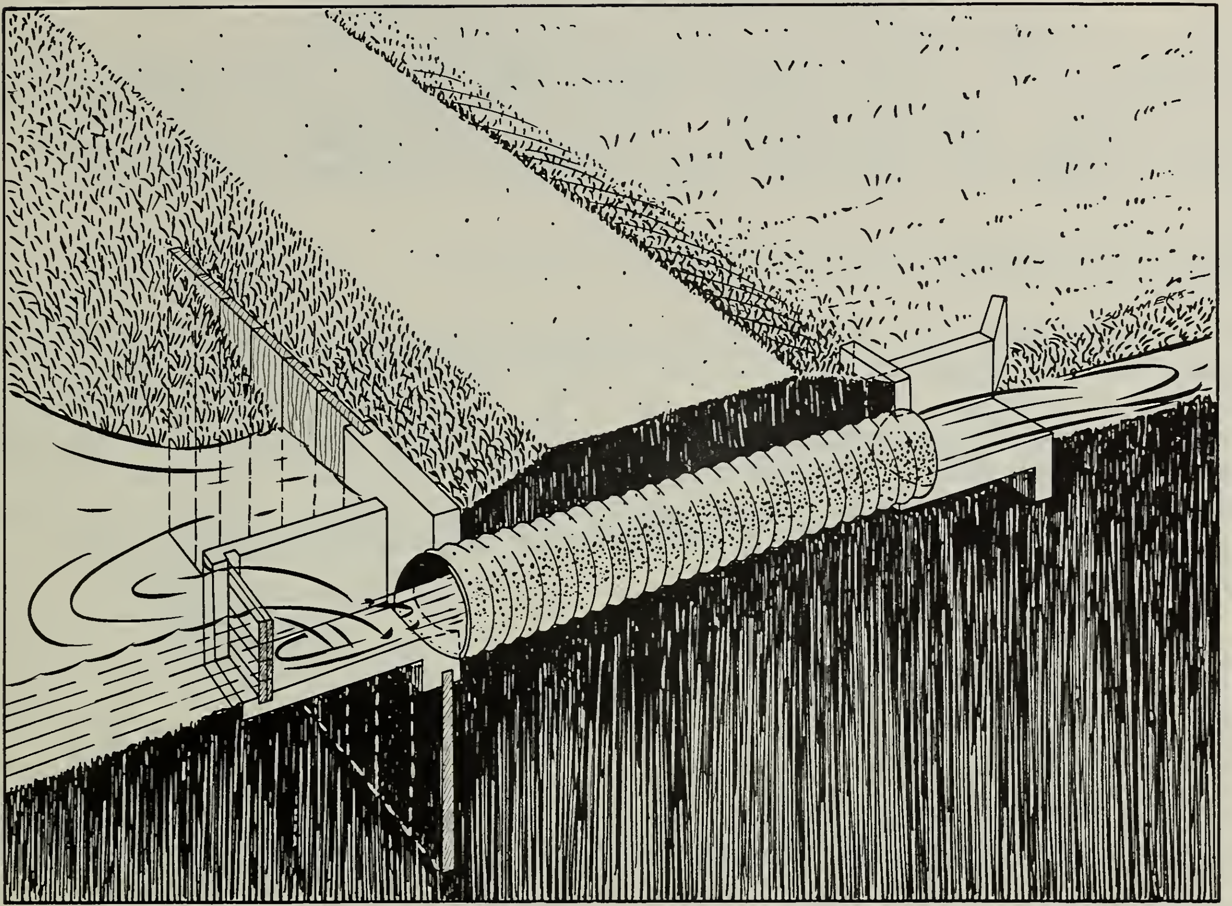
WATER CONTROL STRUCTURES



OPEN TIMBER FLUME



METAL PIPE BOX INLETS



Box-inlet on culvert with stop logs.

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Culvert spillway with stop logs.

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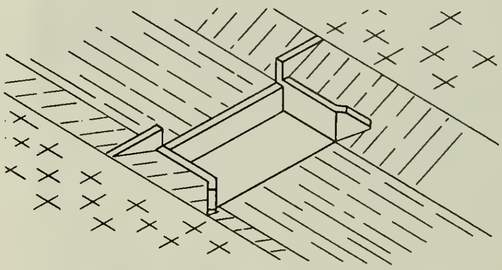
SURFACE WATER INLETS TO DITCHES

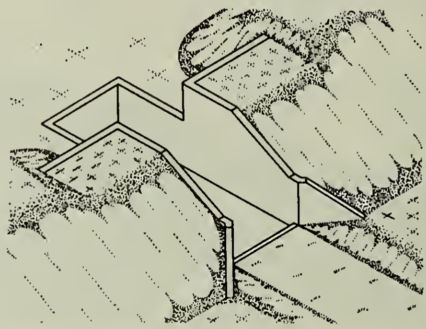
Provisions should always be made for lowering surface water from adjoining fields to the ditch. This is necessary at the head end of the ditch as well as along the banks. Drop spillways, pipe spillways or chutes are the common structures used.

1. Drop Spillways

Drop spillways are adapted to locations where the volume of water to be handled is large. They can also be used as a tile outlet structure. The drop spillway fits conditions where there is no spoil bank and is particularly adapted for protecting the head end of a ditch. Where topography permits, the island-type spillway procedure should be used. The island-type spillway can also be used along the side of a ditch having spoil banks.



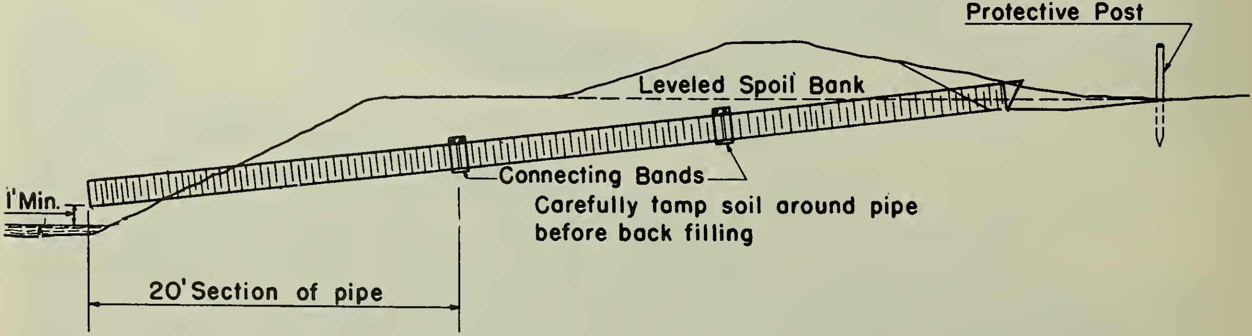
Straight Drop Spillway



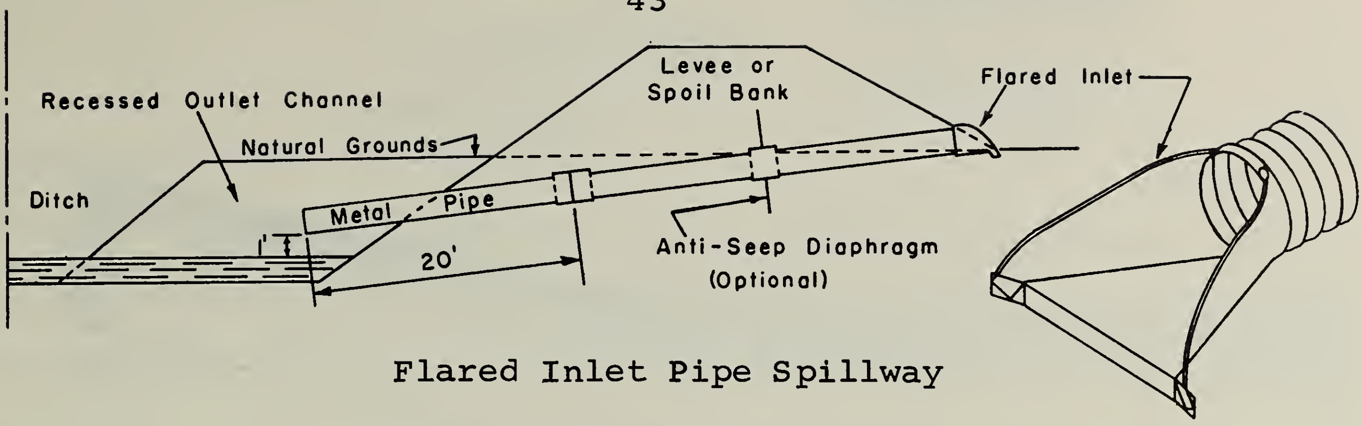
Box Inlet Drop Spillway

2. Pipe Spillways

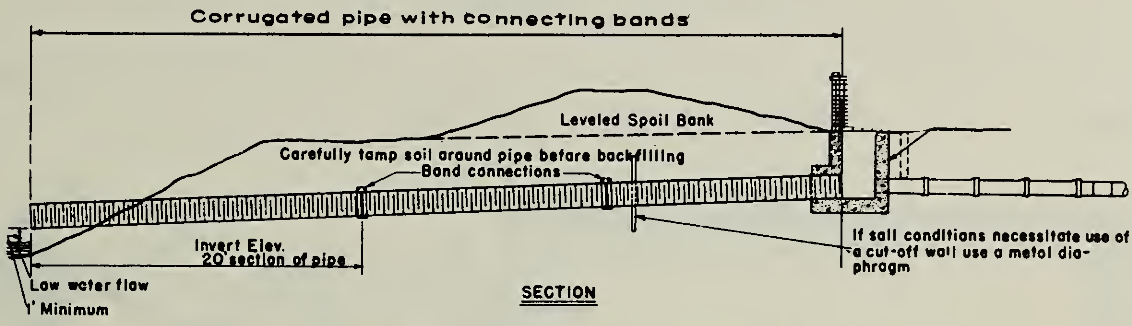
The pipe spillway can be used advantageously to convey water back of levees and continuous spoil banks into a drainage ditch. The hood inlet is most efficient where discharge capacity is a problem. The flared inlet is less efficient but facilitates the passing of field debris such as corn stalks and grasses. The pipe drop inlet is efficient and can be used as a tile outlet.



Hood Inlet Pipe Spillway



Flared Inlet Pipe Spillway

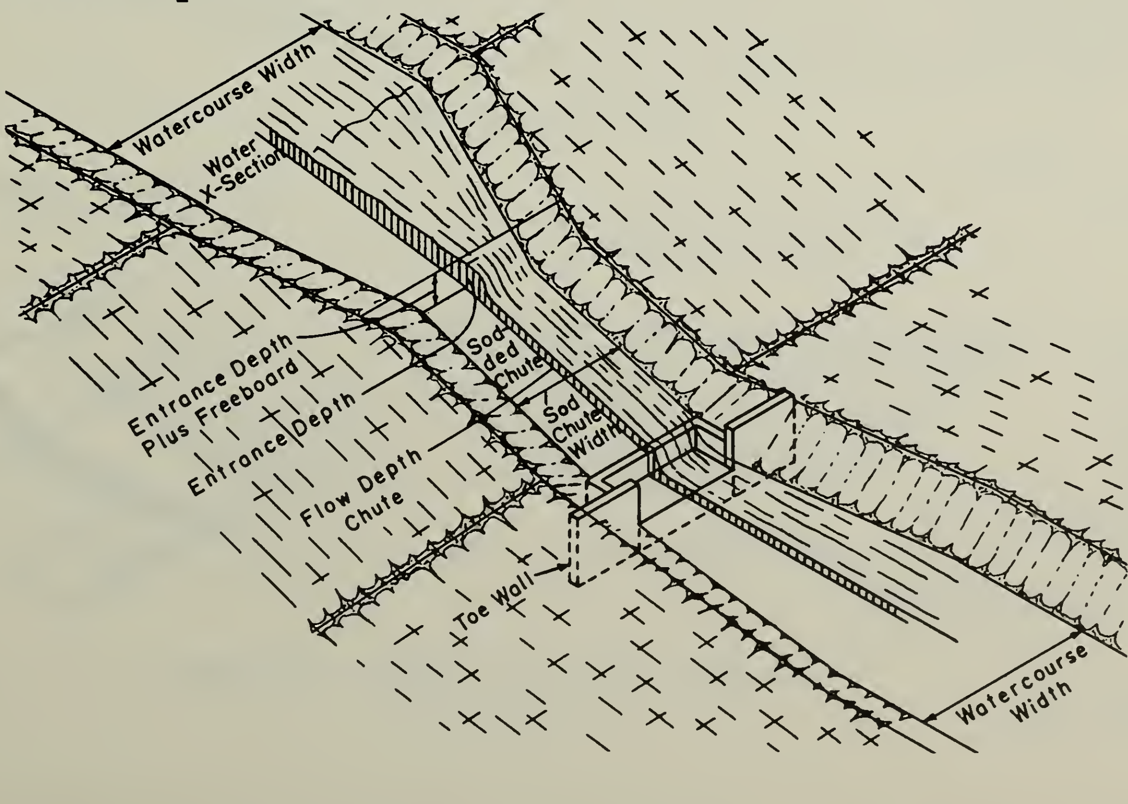


Pipe Drop Inlet Spillway

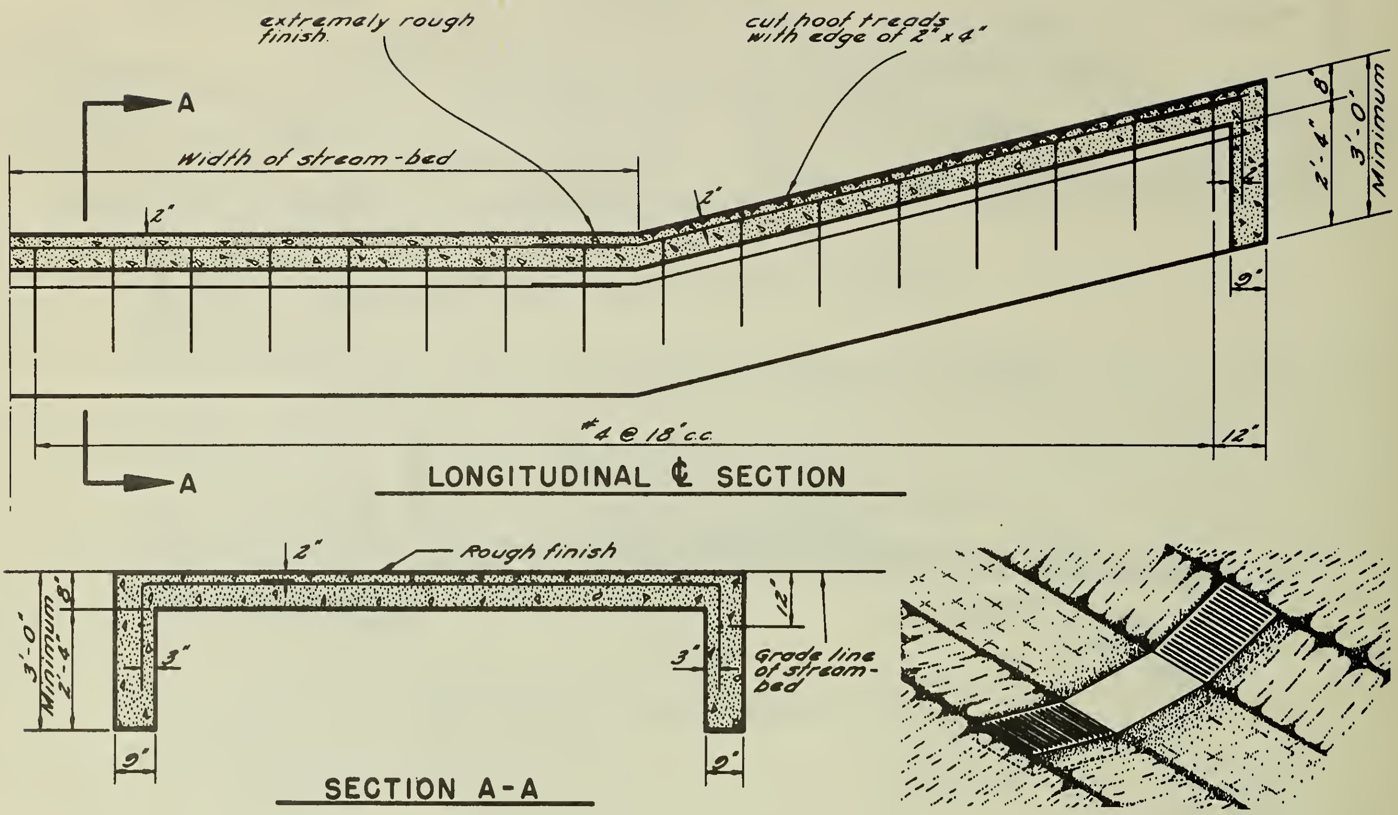
3. <u>Chutes</u>

Chutes can be used at most locations. Material costs are low; however, labor requirements may be high.

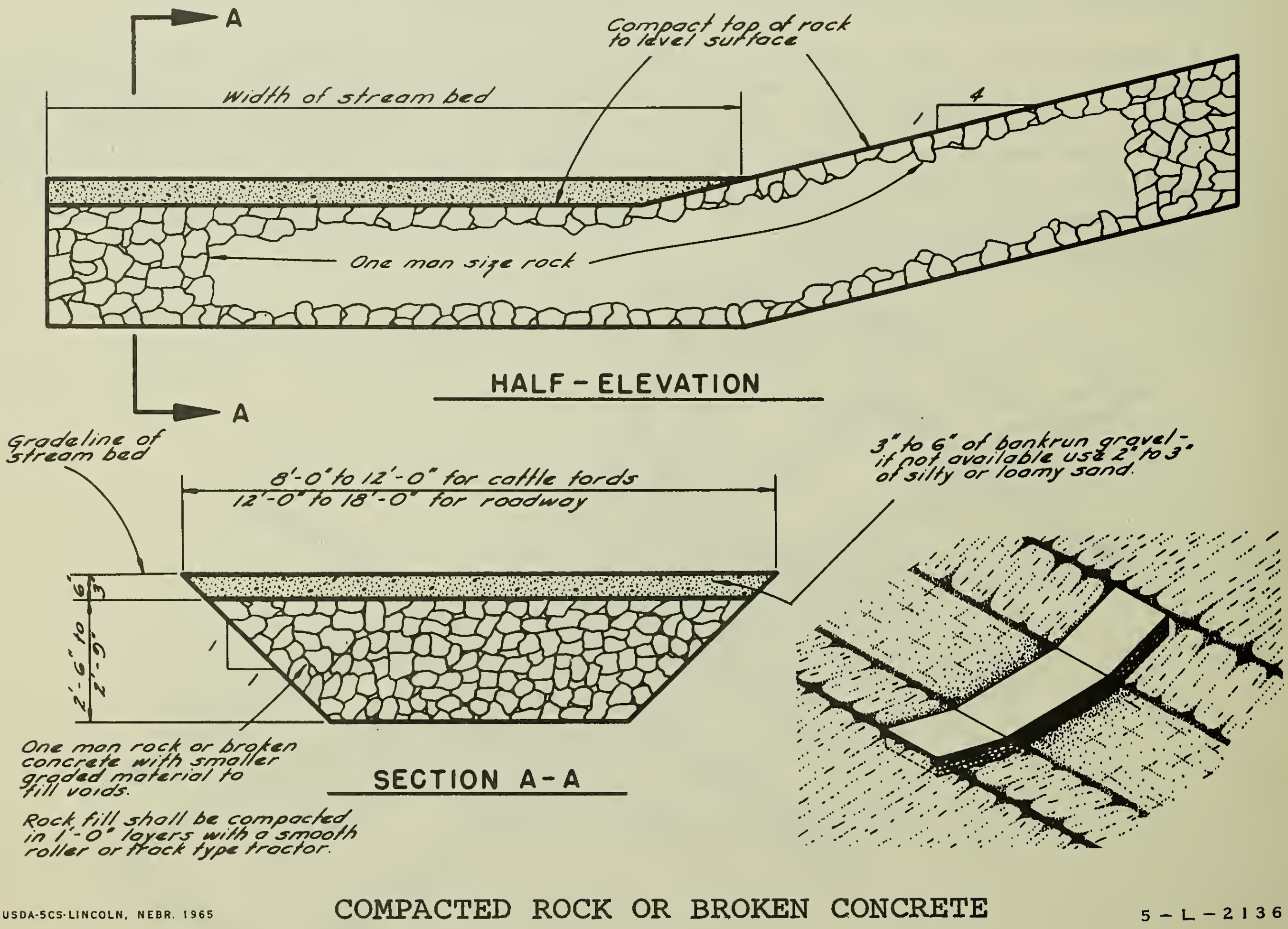
A vegetated chute may be used where the volume of water is small. It should be mowed frequently to maintain a good dense sod. If a vegetated chute is used on a ditch of constant flow, the toe must be raised above normal water level and protected with a toe wall to prevent unraveling of the sod. Where rock is plentiful, a riprap or Gabion outlet structure may be a satisfactory solution.



STREAM FORDS



REINFORCED CONCRETE



COMPACTED ROCK OR BROKEN CONCRETE

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